Q
11
N82X
NH

An Annotated Catalog of the Pyrenomycetes Described by Charles H. Peck

MARGARET E. BARR
University of Massachusetts

CLARK T. ROGERSON
The New York Botanical Garden

STANLEY J. SMITH
and
JOHN H. HAINES
New York State Museum

1986

SMITHSONIAN
AUG 25 1986
LIBRARIES

Bulletin No. 459

New York State Museum

The University of the State of New York
THE STATE EDUCATION DEPARTMENT
Albany, New York 12230

NEW YORK
THE STATE OF LEARNING

Frontispiece: Charles Peck recording perishable fungi in his hotel room in Port Jefferson, Long Island in 1904. Photograph by the mycologist George Atkinson.

An Annotated Catalog of the Pyrenomycetes Described by Charles H. Peck

MARGARET E. BARR
Department of Botany
University of Massachusetts
Amherst, Massachusetts 01003

CLARK T. ROGERSON
The New York Botanical Garden
Bronx, New York 10458

STANLEY J. SMITH[1]

and

JOHN H. HAINES
New York State Museum
Albany, New York 12230

1986

Bulletin No. 459

ISBN 1-55557-005-4
ISSN 0278-3355
New York State Museum

The State Education Department does not discriminate on the basis of age, color, religion, creed, disability, marital status, veteran status, national origin, race, or sex in the educational programs and activities which it operates. Inquiries concerning this policy of equal opportunity and affirmative action should be referred to the Department's Affirmative Action Officer, Education Building, Albany, NY 12234. Phone (518) 473-1265.

The University of the State of New York
THE STATE EDUCATION DEPARTMENT
Albany, New York 12230

---

[1] Deceased July 20, 1978

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of The University *(with years when terms expire)*

1987 MARTIN C. BARELL, *Chancellor,* B.A., I.A., LL.B., LL.D., ... Muttontown
1987 R. CARLOS CARBALLADA, *Vice Chancellor,* B.S., L.H.D., D.Sc. .... Rochester
1986 KENNETH B. CLARK, A.B., M.S., Ph.D., LL.D., L.H.D., D.Sc. .... Hastings on Hudson
1988 WILLARD A. GENRICH, LL.B., L.H.D., LL.D., Litt.D., D.C.S., D.C.L., Sc.D. .... Buffalo
1989 EMLYN I. GRIFFITH, A.B., J.D. .... Rome
1991 JORGE L. BATISTA, B.A., J.D., LL.D. .... Bronx
1986 LAURA BRADLEY CHODOS, B.A., M.A. .... Vischer Ferry
1991 LOUISE P. MATTEONI, B.A., M.A., Ph.D. .... Bayside
1988 J. EDWARD MEYER, B.A., LL.B., L.H.D. .... Chappaqua
1988 FLOYD S. LINTON, A.B., M.A., M.P.A., D.C.L., LL.D. .... Miller Place
1988 SALVATORE J. SCLAFANI, B.S., M.D. .... Staten Island
1989 MIMI LIEBER, B.A., M.A. .... Manhattan
1992 SHIRLEY C. BROWN, B.A., M.A., Ph.D. .... Albany
1990 NORMA GLUCK, B.A., M.S.W., LL.D.. .... Manhattan
1990 THOMAS R. FREY, A.B., LL.B. .... Rochester
1990 JAMES W. MCCABE, Sr., A.B., M.A. .... Johnson City

President of The University and Commissioner of Education
GORDON M. AMBACH

Executive Deputy Commissioner of Education
ROBERT J. MAURER

Deputy Commissioner for Cultural Education
CAROLE F. HUXLEY

Assistant Commissioner for the State Museum
MARTIN E. SULLIVAN

Chief Scientist, Biological Survey
NORTON G. MILLER

INTRODUCTION

Charles Horton Peck (1833-1917) was Botanist at the New York State Museum and its predecessor, the State Cabinet of Natural History, from 1867 to 1915. He was officially State Botanist (a statutory title) from 1883 to 1915. In his yearly reports and papers other than State publications, Peck described a huge number of new species and varieties of fungi and worked in all of the major plant groups. While the majority of fungi that he studied and described were Basidiomycetes, especially agarics and boletes, Peck also described a number of Ascomycetes and Fungi Imperfecti mostly between the years 1870 and 1888. The purpose of this catalog is to provide a comprehensive listing of the species for those Ascomycetes generally termed Pyrenomycetes (but including both Euascomycetes and Loculoascomycetes). Correct citations, synonymies, data on type specimens, and currently accepted generic positions are all included in the catalog. The type specimens from Peck's herbarium, now part of the herbarium of the New York State Museum (NYS), were studied except where noted. When it was necessary, species were transferred to suitable genera, given expanded descriptions or provided with pertinent drawings.

From Peck's own reports and from those of his successor, Homer D. House, who worked at the Museum from 1913 until 1947, some history of Peck's collecting methods and handling of specimens is known. After Peck's appointment as Botanist, he organized the existing specimens in the collection and then attempted to expand the catalog of known species in the State. Since he considered the seed plants to be well-covered by Torrey's flora (1843), Paine's account (1865), and Clinton's notes (1866), and since his own paper on the bryophytes (Peck 1866) had been published, he began an account of the fungi which he continued through retirement. Peck's emphasis on new taxa for the State compelled him to make but few collections of each item, many times only one. In fact, the more common the fungus, the more likely it was collected only once. For each collection he would mount all or part of the material with a characteristic blue label; the remainder, if any, would be wrapped in newspaper and stored for future study, gift, or exchange. These newspaper packets of duplicate material were packeted by Dr. House who usually used the names as they are given in Saccardo's Sylloge Fungorum. Peck apparently considered the month or months of fruiting or sporulating to be the only important chronological data. For this reason the year dates are missing on the majority of his labels and can best be ascertained by checking his notebooks on file at NYS. For those specimens sent to Peck the year date in Peck's notebooks is cited, unless otherwise given in the description or on the label. In cases where a holotype or lectotype has not been previously designated, preference has been given to packets with Peck's notation that spores are mature and to those that include original illustrations. Because Peck or Cooke and Peck did not designate type specimens, many lectotypifications are made in this study.

An attempt has been made to designate precisely the kind of type and to include combined information from the published description, from data on the labels of the specimens, and from information from Peck's notebooks. Host identifications are given as they appear in the type description or on labels and have been equated (in parentheses) with present-day names, only when the old names would cause confusion.

Nearly one hundred taxa were described by M. C. Cooke with C. H. Peck as junior author. These were all described from a series of 401 consecutively numbered specimens sent by Peck to Cooke between 1871 and 1876. Many of these are pyrenomycetes and most of them are portions of larger collections retained at the New York State Museum. Where collections were split with the Cooke herbarium, now part of The Royal Botanic Gardens, Kew, designated as (K), each portion retains the same specimen number. This number is included in the catalog with each Cooke and Peck series. The Peck material at Kew is now integrated into the general herbarium and only a few of these have been checked by the authors. These Kew portions should be treated as the holotype specimens of Cooke and Peck species, but it should be borne in mind that the more abundant portion may be available from the Peck herbarium at the New York State Museum.

In addition to sending portions of gatherings to Cooke, Peck also sent portions to J. B. Ellis, William Phillips, Charles B. Plowright, Worthington G. Smith, Elias Fries, Felix de Thumen, W. A. Gerard, G. W. Clinton and perhaps others during the early years of his work on fungi. After Peck's death, Homer House sent portions of many types to The New York Botanical Garden (NY) and the National Fungus Collections (BPI). Rogerson has verified the presence of the specimens in NY. All of this information is recorded in Peck's notebooks and in House's correspondence at NYS. An attempt has been made to note when portions of types were sent out, but, except for a few specimens at K, the survival of this material in herbaria other than NYS and NY has not been checked. These other portions of types would be of great importance in the event that the NYS portion is lost or destroyed.

An early inventory of the Peck herbarium was done in 1905 by Peck's assistant at that time, Stewart Burnham. This document, along with other valuable papers were recently received from Mr. Robert Dirig of the Bailey Hortorium of Cornell University. This inventory shows that some of the specimens which cannot now be located in the Peck herbarium were missing as early as 1905 or may never have been retained by Peck in the first place. This information is included in this catalog under the species involved.

The New York State Museum has a large number of original illustrations of fungi done by Peck. Many of these pencil or pencil and watercolor drawings were done from type specimens. A number of these are reproduced in this catalog (Figs. 104-132). The illustrations have been selected on taxonomic and not artistic considerations, and have been redrawn because the originals are too faint to reproduce well. These illustrations were chosen because they were done from type material, have not been published before and are of taxa that have not been placed in synonymy.

Over 300 taxa are included in this study and new combinations are proposed for 25 of these. The species represent more than 100 genera which are listed in the following outline of orders and families. The orders and families are for the most part those of Barr (1976, 1979b, 1983) or in some cases are revised from these outlines. The publication dates given for Peck's works are those determined by Petersen in Vogelenzang (1980). The year in parentheses is the year covered in the report and the year without parentheses is the actual date of publication for taxonomic priority.

The current correct name, as far as can be determined by the authors, for each taxon, is printed in **boldface roman type** in each entry.

OUTLINE OF ORDERS, FAMILIES, AND GENERA IN LISTING

Class Ascomycetes
Coryneliales
    Coryneliaceae: *Caliciopsis*
Erysiphales
    Erysiphaceae: *Erysiphe, Microsphaera, Podosphaera, Sphaerotheca, Uncinula, Uncinuliella*
Diaporthales
    Gnomoniaceae: *Anisogramma, Diaporthella, Ditopellopsis, Mamianiella*
    Valsaceae: *Amphiporthe, Cryptodiaporthe, Diaporthe, Leucostoma, Ophiovalsa, Plagiostoma, Valsa, Valsella*
    Pseudovalsaceae: *Allantoporthe, Chapeckia, Phragmodiaporthe, Pseudovalsa*
    Melanconidaceae: *Cryptosporella, Melanconis, Prosthecium*
Coronophorales
    Coronophoraceae: *Nitschkia*
Sordariales
    Sordariaceae: *Podosordaria, Podospora, Schizothecium*
    Lasiosphaeriaceae: *Lasiosphaeria, Phaeotrichosphaeria*
    Melanosporaceae: *Scopinella*
    Chaetomiaceae: *Chaetomium*
    Position uncertain: *Chaetosphaerella, Helminthosphaeria*
Calosphaeriales
    Calosphaeriaceae: *Enchnoa, Jattaea, Romellia*
Hypodermatales
    Hypodermataceae: *Lophodermium*
Clavicipitales
    Clavicipitaceae: *Atkinsonella, Barya, Cordyceps*
Pezizales
    Pyronemataceae: *Thelebolus*
Helotiales
    Dermataceae: *Dermea*
    Leotiaceae: *Claussenomyces, Holwaya*

Xylariales
    Amphisphaeriaceae: *Amphisphaeria*, *Apiorhynchostoma*, *Apodothina*, *Discostroma*, *Phomatospora*, *Valsaria*
    Diatrypaceae: *Cryptosphaeria*, *Diatrype*, *Diatrypella*, *Endoxylina*, *Eutypella*
    Coniochaetaceae: *Coniochaeta*
    Boliniaceae: *Camarops*
    Xylariaceae: *Anthostomella*, *Hypoxylon*, *Rosellinia*, *Xylaria*
    Acrospermataceae: *Acrospermum*

Phacidiales
    Leptopeltidaceae: *Leptopeltis*
Phyllachorales
    Melogrammataceae: *Phyllachora*, *Polystigma*
    Physosporellaceae: *Hyponectria*

Hypocreales
    Hypocreaceae: *Hypocrea*, *Hypomyces*, *Nectria*, *Thyronectria*
Trichosphaeriales
    Trichosphaeriaceae: *Litschaueria*, *Melanopsamma*, *Niesslia*
    Position uncertain: *Ceratostomella*, *Rhynchostoma*
Lecanorales
    Position uncertain: *Dactylospora*

Class Loculoascomycetes
Myriangiales
    Myriangiaceae: *Myriangium*
    Elsinoaceae: *Elsinoe*
    Arthoniaceae: *Arthothelium*
    Cookellaceae: *Cookella*
Asterinales
    Parmulariaceae: *Hysterostomella*
Dothideales
    Pseudosphaeriaceae: *Wettsteinina*
    Dothioraceae: *Delphinella*, *Dothiora*, *Scirrhia*
    Dothideaceae: *Mycosphaerella*
Chaetothyriales
    Trichothyriaceae: *Trichothyrina*
    Herpotrichiellaceae: *Berlesiella*

Pleosporales

- Botryosphaeriaceae: *Botryosphaeria, Neodeightonia*
- Patellariaceae: *Holmiella, Lecanidion, Rhytidhysteron, Tryblidaria*
- Hysteriaceae: *Hysterium, Hysterographium*
- Pleosporaceae: *Kirschsteiniothelia, Pleospora*
- Venturiaceae: *Gibbera, Phaeocryptopus, Platychora, Protoventuria, Pyrenobotrys, Venturia*
- Tubeufiaceae: *Podonectria, Tubeufia*
- Phaeosphaeriaceae: *Bertiella, Chaetoplea, Comoclathris, Diapleella, Didymella, Leptosphaeria, Massariosphaeria, Metameris, Neopeckia, Nodulosphaeria, Phaeosphaeria, Teichospora*
- Massarinaceae: *Herpotrichia, Massarina*
- Pleomassariaceae: *Asteromassaria, Pleomassaria, Splanchnonema*
- Cucurbitariaceae: *Cucurbitaria*
- Dimeriaceae: *Dimerium*
- Sporormiaceae: *Sporormiella*

Melanommatales

- Melanommataceae: *Byssosphaeria, Melanomma, Pseudotrichia*
- Massariaceae: *Dothivalsaria, Massaria*
- Lophiostomataceae: *Lophiostoma*
- Didymosphaeriaceae: *Didymosphaeria*
- Fenestellaceae: *Fenestella, Karstenula, Thyridaria*
- Mytilinidiaceae: *Mytilinidion*

abbreviata, (***Microsphaera***) Peck, Ann. Rep. New York State Mus. 28: 64. Pl. 2, Figs. 4-5. (for 1874) 1876.
Type specimen (holotype): on leaves of *Quercus*, Buffalo, Erie Co., New York, 1874, G. W. Clinton.

Salmon (1900) considered this to be a synonym of *Microsphaera alni* (Wallr.) Salmon var. *alni*; the earlier epithet is **M. penicillata** (Wallr.:Fr.) Lév. var. **penicillata**, according to W. B. Cooke (1952). Blumer (1967) synonymized *M. abbreviata* with *Microsphaera alphitoides* Griffin & Maublanc.

acerina, (***Valsa***) Peck, Ann. Rep. New York State Mus. 28: 74. (for 1874) 1876.
Diaporthe acerina (Peck) Sacc , Syll. Fung. 1: 611. 1882.
Valsa albocincta Cooke & Peck in Cooke, Proc. Acad. Nat. Sci. Philadelphia 29: 120. 1877.
Type specimen (holotype): on branches of *Acer spicatum*, Indian Lake, Hamilton Co., New York, July 1873, C. H. Peck (duplicate sent to Cooke 23 July 1873 as #317).

The disposition as **Diaporthe acerina** was confirmed by Wehmeyer (1933). Fig. 104.

acerinum, (***Hysterographium***) Peck, Bull. New York State Mus. 167: 43. 1913.
Type specimen (holotype): on decorticated *Acer glabrum*, Boulder, Boulder Co., Colorado, 11 Aug 1911, E. Bartholomew #4474 (duplicate at FH).

This is a form of **Hysterographium elongatum** (Wahlenb.) Corda, according to the emended description furnished by Zogg (1943, 1962).

acrocystis, (***Valsa***) Peck, Ann. Rep. New York State Mus. 33: 34. Pl. 2, Figs. 19-22. (for 1879) 1883.
Melanconiella acrocystis (Peck) Berk. & Vogl., Syll. Fung. Addit. 1-4: 128. 1886.
Melanconis acrocystis (Peck) Ellis & Everh., N. Amer. Pyrenomyc. p. 526. 1892.
Type specimen (holotype): on branches of *Betula lenta*, North Greenbush, Rensselaer Co., New York, May 1879, C. H. Peck.

The species was accepted as *Melanconis acrocystis* and was illustrated by Wehmeyer (1941). Revisionary studies of members of the Diaporthales provided the transfer to **Prosthecium acrocystis** (Peck) Barr, Mycol. Mem. 7: 186. 1978.

acuta, (***Xylaria***) Peck, Ann. Rep. New York State Mus. 25: 101. (for 1871) 1873.
Type specimen (holotype): on mossy decaying logs, Greig, Lewis Co., New York, Sept 10, 1910; C. H. Peck (duplicate sent to NY in 1935 and is at NY).

This is a distinctive species of *Xylaria*: the stipe is villose as in *X. hypoxylon* Grev., but **Xylaria acuta** differs from the former by having larger ascospores containing a spiral rather than a straight germ slit. Fig. 105.

adherens var. americana, (***Valsella***) Peck, Ann. Rep. New York State Mus. 40:68. (for 1886) 1887.
Type specimen (holotype): on branches of *Betula populifolia*, Sandlake, Rensselaer Co., New York, Sept 1886, C. H. Peck.

The fungus is synonymous with **Diatrypella decorata** Nits. It differs from *D. favacea* (Fr.) Ces & de Not. by the stroma surface which is blackened rather than whitish.

adusta, (***Diatrype***) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 58. (for 1875) 1878.
Anthostoma adustum (Cooke & Peck) Sacc., Syll. Fung. 1:307. 1882.
Type specimen (isotype): on dead branches, New Baltimore, Green Co., New York, no date given, E. C. Howe, New York; portion also at K, accompanied by a small illustration of spores and asci. It contains 2 pieces of substrate, mounted separately, but apparently part of the same gathering (sent to Cooke 27 June 1871 as #48).

The ascospores of the fungus are xylariaceous in pigmentation and in the presence of an elongate germ slit. The transfer of the species to *Anthostomella* is proposed; it was not treated by Francis (1975).

Anthostomella adusta (Cooke & Peck) Barr, comb nov. Figs. 84-86.

Stromata visible as blackened areas up to 1.5 cm diam beneath periderm, composed of blackened upper region and whitish interior of hyphae mixed with host cells surrounding 1 to 3 perithecia; perithecia globose depressed, 500-650 μm diam, 400 μm high, ostioles short and broadly papillate, canal periphysate; wall brown externally and 16-20 μm wide, hyaline internally and 12 μm wide; numerous layers of compressed cells, upper wall grown together with stroma tissue and up to 170 μm wide. Asci 120-150 × 16 5-22 μm, unitunicate, elongate oblong, base tapered and blunt, apex with refractive apical annulus, nonchitinoid, amyloid; paraphyses numerous, septate. Ascospores 22-27 5(– 33) × 11-13(–15) μm, rich brown, broadly ellipsoid, straight or inequilateral, one-celled, a single large globule or numerous small ones, wall smooth, with spiral germ slit running throughout length, surrounded by narrow gel coat, 1-3 μm wide, overlapping uniseriate or partially biseriate in the ascus.

aesculi, (***Laestadia***) Peck, Ann. Rep. New York State Mus. 39: 51. Pl. 2, Figs. 15-19. (for 1885) 1887.

Guignardia aesculi (Peck) Stewart, Phytopathology 6: 9. 1916.
Botryosphaeria aesculi (Peck) Barr, Contr. Univ. Michigan Herb. 9: 561. 1972.
Type specimen (holotype): on petioles of *Aesculus hippocastanum*, Albany, Albany Co., New York, 20 May 1885, G. W. Clinton.

aggregata, (*Erysiphella*) Peck, Ann. Rep. New York State Mus. 28: 63. Pl. 2, Figs. 1-3. (for 1874) 1876.
Erysiphe aggregata (Peck) Farlow, Bull. Bussey Inst. 2:227. 1878.
Type specimen (holotype): on fertile aments of *Alnus*, North Greenbush, Rensselaer Co., New York, May 1870, C. H. Peck.

This species was the basis for the genus *Erysiphella* Peck which presumably differed from *Erysiphe* in the lack of mycelial appendages. However, such appendages are present and Salmon (1900) also relegated *Erysiphella* to synonymy with *Erysiphe*. **Erysiphe aggregata** is a valid species.

albidostoma, (*Sphaeria*) Peck, Ann. Rep. New York State Mus. 32: 51. (for 1878) 1880.
Herpotrichia albidostoma (Peck) Sacc., Syll. Fung. 9: 857. 1891.
Herpotrichia leucostoma Peck, Bull. New York State Mus. 1(2): 23. 1887. (an avowed substitute of the epithet.)
Type specimen (holotype): on dead branches of *Acer spicatum*, Griffins, Delaware Co., New York, Sept 1877, C. H. Peck.

Bose (1961), Müller and von Arx (1962), and Sivanesan (1971) included *Sphaeria albidostoma* among the synonyms of *Herpotrichia schiedermayeriana* Fuckel. However, these authors did not cite Peck's type specimen, and apparently based their synonymy on later specimens which were not identical with the type. *Herpotrichia schiedermayeriana* differs from *S. albidostoma* especially in structure of the ascocarp. *Sphaeria albidostoma* is identical with **Herpotrichia macrotrichia** (Berk. & Br.) Sacc. Figures 45, 46 illustrate the species. More information on this and related taxa is presented in Barr (1984).

albocincta, (*Valsa*) Cooke & Peck in Cooke, Proc. Acad. Nat. Sci. Philadelphia 29: 120. 1877.
Diaporthe albocincta (Cooke & Peck) Sacc., Syll. Fung. 1: 610. 1882.
Type specimen: on *Acer spicatum*, New York, Peck (Portion sent to Cooke 23 July 1873 as #317).

Wehmeyer (1933) synonymized the species with **Diaporthe acerina** (Peck) Sacc. Cooke created an obligate synonym when he used a portion of Peck's type of *Valsa acerina* Peck as the basis of *V. albocincta* Cooke & Peck.

album, (**Acrospermum**) Peck, Ann. Rep. New York State Mus. 32:38. (for 1878) 1880.
Type specimen (holotype): on dead stems of *Aralia racemosa*, Catskill Mts., New York, July 1878, C. H. Peck.

This is a distinct species, related to *A. compressum* Tode:Fries by the surface cells of ascoma wall forming textura angularis, differing from *A. compressum* by pallid or whitish color.

alnea, (*Cucurbitaria*) Peck, Ann. Rep. New York State Mus. 28: 75. (for 1874) 1876.
Otthia alnea (Peck) Sacc., Syll. Fung. 1: 740. 1882.
Gibberidea alnea (Peck) Wehm., Canad. J. Research C. 20: 856. 1942.
Massarina alnea (Peck) Holm, Svensk Bot. Tidskr. 62: 226. 1968.
Type specimen (holotype): on branches of *Alnus*, Center (= Karner), Albany Co., New York, May 1874, C. H. Peck.

This species differs from species of *Massarina* in having numerous ascomata together on subiculum, widely erumpent from the branch, and in trabeculate pseudoparaphyses in the centrum. Barr (1984) transferred *C. alnea* as **Byssosphaeria alnea**. Figs. 35, 36.

alni, (*Dothidella*) Peck, Ann. Rep. New York State Mus. 40;71. (for 1886) 1887.
Platychora alni (Peck) Petrak, Ann. Mycol. 32: 318. 1934.
Type specimen (holotype): on dead leaves of *Alnus viridis*, Mount Marcy, Essex Co., New York, June 1886, C. H. Peck.

The fungus was described in detail by Petrak (1934), and by Barr (1968).

alni, (*Valsa*) Peck, Ann. Rep. New York State Mus. 25:103. (for 1871) 1873. Fig 106.
Engizostoma alni (Peck) O. Kuntze, Rev. Gen. Pl. 3: 473. 1898.
Type specimen (holotype): on branches of *Alnus rugosa* (now *A. serrulata*), Center (= Karner), Albany Co., New York, April 1871, C. H. Peck.

Ellis and Everhart (1892) considered the name to be a synonym of *Valsa americana* Berk. & Curt. The species scarcely differs from **Valsa melanodiscus** Otth.

alnicola, (*Sphaerella*) Peck, Ann. Rep. New York State Mus. 40: 68, 69. (for 1886) 1887.
Mycosphaerella alnicola (Peck) Jaap, Ann. Mycol. 15: 105. 1917. House also made the combination in Bull. New York State. Mus. 233-234: 25. 1920.
Type specimen (holotype): on leaves of *Alnus viridis*, Mount Marcy, Essex Co., New York, June 1886, C. H. Peck. Fig. 107.

altipeta, (*Sphaeria*) Peck, Bot. Gaz. 5: 36. 1880.

Rhynchostoma altipeta (Peck) Sacc., Syll. Fung. 1: 731. 1882.

Entosordaria altipeta (Peck) v. Höhnel, Sitzungsber. Akad. Wiss. Wien, Math -Naturw. Kl. Abt. I, 129: 166. 1920.

Type specimen (holotype): on decaying wood, Mt. Washington, New Hampshire, 1879, C. G. Pringle #328 bis.

The type is identical with and the names are synonyms of **Apiorhynchostoma curreyi** (Rabenh.) Müller in Müller & von Arx, Beitr. Kryptogamenfl. Schweiz. 11(2):707. 1962.

ampelopsidis, (*Uncinula*) Peck, Trans. Albany Inst. 7: 216. 1872; Ann. Rep. New York State Mus. 25: 96. (for 1871) 1873.

Type specimens (syntypes): on leaves of *Ampelopsis quinquefolia*, Buffalo, Erie Co., New York, 1871, G. W. Clinton. This packet contains two smaller packets labeled "2 Oct. 18." and "3 Sept. 2" plus a larger quantity of leaves without collection information; same host, North Greenbush, Rensselaer Co., New York, Aug 1871, C. H. Peck; same host and locality, Sept 1871, C. H. Peck.

Salmon (1900) synonymized the name under **Uncinula necator** (Schw.) Burrill.

angulare, (*Diatrype*) Peck, Bot. Gaz. 5: 36. 1880.

Valsaria angulare (Peck) Sacc., Syll. Fung. 1:745. 1882.

Type specimen (holotype): on bark of *Tilia americana*, New Haven, Addison Co., Vermont, 17 May 1879, C. G. Pringle, #209.

The collection agrees in all respects with **Dothivalsaria megalospora** (Auersw.) Petrak, Sydowia 19: 283. 1965 [1966].

anomala, (*Diatrype*) Peck, Ann. Rep. New York State Mus. 28: 72. (for 1874) 1876.

Cryptosporella anomala (Peck) Sacc., Syll. Fung. 1: 470. 1882.

Cryptospora anomala (Peck) Ellis & Everh., N. Amer. Pyrenomyc. p. 531. 1892.

Apioporthe anomala (Peck) v. Höhnel, Sitzungsber. Akad. Wiss. Wien, Math -Naturw. Kl. Abt. I, 126: 281. 1917.

Anisogramma anomala (Peck) Müller in Müller & von Arx, Beitr. Kryptogamenfl. Schweiz, 11(2): 769. 1962.

Type specimen (holotype): on living branches of *Corylus*, Albany, Albany Co., New York, May 1874, C. H. Peck.

Müller in Müller and von Arx (1962) described and discussed this fungus and its synonymy. Peck's species was the type of *Apioporthe* v. Höhnel, which was described a year later than *Anisogramma* Theiss. & Sydow.

apiculata, (*Hypocrea*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 57. (for 1875) 1878.

Clintoniella apiculata (Cooke & Peck) Sacc., Syll. Fung. 16: 588. 1902.

Hypomyces apiculatus (Cooke & Peck) Seaver, Mycologia 2:73. 1910.

Type specimen (isolectotype): on ground and rocks, Catskill Mts., July (1870), C. H. Peck; (original material): Sand Lake, Rensselaer Co., C. H. Peck.

In the single packet at NYS labelled in Peck's handwriting with this name are (1) a smaller packet containing fragments of the fungus and the data "209, *Hypocrea*, Catskills, July" plus a drawing of spores, and (2) a small portion of the fungus glued to a card bearing no data (possibly the Sand Lake collection?). Both portions are the same species and both are identical to **Hypomyces armeniacus** Tulasne, Ann. Sci. Nat. Bot. IV, 13: 12. 1860. Seaver (1910) indicated that the type locality was the Catskill Mountains. A small collection from the Cooke herbarium, together with a drawing were located at K. Peck's notebooks indicate that this is a portion of the Catskill Mountains collection and was sent to Cooke 21 Feb 1872 as #209.

apocyni, (*Nectria*) Peck, Bull. Buffalo Soc. Nat. Sci. 1: 71. 1873; Ann. Rep. New York State Mus. 26: 84, 85. (for 1872) 1874.

Cucurbitaria apocyni (Peck) O. Kuntze, Rev. Gen. Pl. 3: 460 1898.

Type specimen (holotype): at base of dead stems of *Apocynum cannabinum*, North Greenbush, Rensselaer Co., New York, Oct 1872, C. H. Peck.

Nectria apocyni is a distinctive species. Asci are clavate, 55-80 × 11-13 μm, with apical, nonchitinized ring; ascospores fusoid-ellipsoid, 18-23 × 5 μm, two-celled. Fig. 108. Samuels (1976) gives more detailed information.

arbuticola, (*Sphaerella*) Peck, Bull. Torrey Bot. Club 10: 75. 1883.

Mycosphaerella arbuticola (Peck) Barr, Contr. Univ. Michigan Herb. 9: 587. 1972.

Type specimen (holotype): on leaves of *Arbutus menziesii*, Santa Cruz, Santa Cruz Co., California, July 1881, C. G. Pringle #124.

arbutifoliae, (*Sphaerella*) Peck, in herb. ined.

Mycosphaerella arbutifoliae House, Bull. New York State Mus. 233-234: 26. 1920, *nomen nudum*.

This herbarium name was never validated by Peck as far as we can determine. Two collections are in the herbarium: (1) on leaves of *Pyrus arbutifolia*, Center (= Karner), Albany Co., June, C. H. Peck; (2) on leaves of *Pyrus* (*Aronia*) *melanocarpa*, Karner, Albany Co., 22 April 1915, H. D. House.

arceuthobii, (Sphaeria) Peck, Ann. Rep. New York State Mus. 27: 111. Pl. 1, Figs. 10-14. (for 1873) 1875.

Wallrothiella arceuthobii (Peck) Sacc., Syll. Fung. 1: 455. 1882.

Type specimen (holotype): parasitic on female plants of *Arceuthobium pusillum* Peck on *Picea mariana*, Forestburgh, Sullivan Co., N. Y., Sept 1873, C. H. Peck (duplicate sent to G. W. Clinton 30 Oct 1873 as #81; Ellis 1 Nov 1876).

Weir (1915) provided a detailed description of the species on western hosts, while Dowding (1931) gave some details of infection and development of the fungus in Manitoba and Alberta. Kuijt (1969) illustrated aspects of the life cycle and some of the variations which occur in the morphology of *Wallrothiella arceuthobii.* He recognized that the species could be placed in the Coryneliaceae. Kuijt pointed out that *W. arceuthobii* differed from species of *Caliciopsis* in the absence of a perithecial stalk; however, Barr regards *Caliciopsis* as the most suitable disposition for *Wallrothiella arceuthobii.*

Caliciopsis arceuthobii (Peck) Barr, comb. nov. Figs. 58, 59.

Ascomata developing from stromatic tissue which penetrates deep within fruits of host, forming a botryose cluster, shining brown, short columnar or irregular, 150-246 μm diam, 308-540 μm high, apex rounded, opening by irregular pore; wall of two distinct layers: outer ca. 20 μm wide, dark brown, layers of slightly compressed cells, in gel matrix, inner ca. 15 μm wide, light brown to hyaline, layers of compressed cells, surrounding the ovate locule. Asci arising from base of locule, forming layers of varying ages, upper portion of locule occupied by loose asci and ascospores; asci 16 5-27 × 6-9 μm, ovate or oblong, unitunicate, tapering below to short or somewhat elongate stipe, eventually stipe and finally ascus wall deliquescent, without apical apparatus, aparaphysate. Ascospores 3 5-6 μm, hyaline to light brown young, becoming dull blackish gray, black in mass, globose or subglobose, 1-celled, minutely apiculate, contents with one large globule, wall at maturity darkened and irregularly roughened, crowded in the ascus.

Caliciopsis arceuthobii occurs on other species of *Arceuthobium* parasitic on species of *Pinus, Pseudotsuga, Abies,* and *Picea,* and has been reported in the literature from Manitoba, Saskatchewan, Alberta, Michigan, Idaho, Montana, Oregon, and Arizona.

aridophila, (Teichospora) Peck, Bot. Gaz. 7:57. 1882.

Teichospora xerophila Peck in Sacc., Syll. Fung. 2: 299. 1883.

Type specimen (lectotype): on bleached surface of dry wood, Arizona, 13 April 1881. C. G. Pringle.

In the herbarium at NYS two collections bear this name. One, on *Juniperus virginiana,* with collection data "S. E. Colorado, 30 March 1881, C. G. Pringle #22" was marked TYPE, apparently by House. This collection is a species of *Chaetoplea.* It differs from the collection that we designate as lectotype, and will be renamed when revisionary studies of the members of the genus are completed. The data with the second collection are "Arizona, 13 April, 1881, C. G. Pringle #43," and the packet is marked SYNTYPE. This information agrees more nearly with that given in the type description: "Bleached surface of dry wood. Arizona. May. Pringle," and the specimen itself conforms more nearly to Peck's description. The asci are short and broadly clavate, unlike the cylindric asci of *Teichospora obducens* (Fr.) Fuckel, to which Peck compared his species. The Arizona fungus is congeneric with *T. trabicola* Fuckel, the type of the genus, according to structure of ascoma peridium, locule, and asymmetric ascospores. It is retained as a species of *Teichospora,* and is illustrated by Figs. 30-32 .

asparagi, (Leptosphaeria) Peck, Ann. Rep. New York State Mus. 40: 70. (for 1886) 1887.

Type specimen (holotype): on stems of *Asparagus,* Menands, Albany Co., New York, Oct 1886, C. H. Peck.

Leptosphaeria asparagi is identical with *Trichometasphaeria gloeospora* (Berk. & Currey) L. Holm (Barr in Bigelow and Barr 1960). The species of *Trichometasphaeria* are scarcely separable from those of *Massarina,* and Barr would combine them under the older genus. The combination **Massarina gloeospora** (Berk. & Currey) Barr, comb. nov. is proposed. (Basionym: *Sphaeria gloeospora* (sic) Berk. & Currey in Berk. & Broome, Ann. Mag. Nat. Hist. ser. 3, 7: 454. 1861.)

atrogrisea, (Didymosphaeria) *(Amphisphaeria)* Cooke & Peck in Cooke, Grevillea 17: 92. 1889.

Microthelia atrogrisea (Cooke & Peck) O. Kuntze, Rev. Gen. Pl. 3: 498. 1898.

Type specimen (isolectotype): originally as *Sphaeria atrogrisea,* on bark of *Quercus alba,* Bethlehem, Albany Co., New York, May, C. H. Peck; (syntype): on oak bark, Poughkeepsie, Dutchess Co., New York, W. R. Gerard, #56 (portion sent to Cooke prior to 6 May 1871 as #7).

According to Ellis and Everhart (1892) the fungus is the same as *Massariella bufonia* (Berk. & Br.) Speg. The correct generic disposition in **Amphisphaeria** is **A. bufonia** (Berk. & Br.) Ces. & de Not.

atropuncta, (Diaporthe) Peck, Bull. New York State Mus. 131: 20. 1909.

Chorostate atropuncta (Peck) Sacc. & Trotter, Syll. Fung. 22: 376. 1913.

Type specimen (holotype): on branches of *Tilia americana*, Alcove, Albany Co., New York, April 1893, C. L. Shear, #123.

Wehmeyer (1933) consigned this to synonymy with *Diaporthe tiliacea* (Ellis) v. Hohnel. The most recent disposition is **Phragmodiaporthe tiliacea** (Ellis) Barr, Mycol. Mem. 7: 155. 1978.

***aurantiaca*, (*Hypocrea*)** Peck, Ann. Rep. New York State Mus. 51: 295. (for 1897) 1898.

Type specimen (holotype): on *Polyporus chioneus*, Gansevoort, Saratoga Co., New York, July 1897, C. H. Peck.

Hypocrea aurantiaca is a synonym of **Hypocrea pallida** Ellis. & Everh., J. Mycol. 2: 65. 1886.

***balsamea*, (*Nectria*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 26: 84. (for 1872) 1874 (*nomen nudum*); Cooke & Peck in Cooke, Grevillea 12: 81. 1884.

Calonectria balsamea (Cooke & Peck) Sacc., Syll. Fung. 9: 986. 1891.

Cucurbitaria balsamea (Cooke & Peck) O. Kuntze, Rev. Gen. Pl. 3: 460. 1898.

Scoleconectria balsamea (Cooke & Peck) Seaver, Mycologia 1: 200. 1909.

Thyronectria balsamea (Cooke & Peck) Seeler, J. Arnold Arb. 21: 442. 1940.

Type specimen (isotype): on bark of *Abies balsamea*, North Elba, Essex Co., New York, Aug 1871, C. H. Peck (portion sent to Cooke 18 Nov 1871 as #174. This specimen was subsequently lost but a portion of the type from the Plowright herbarium is now at K. A duplicate was sent to NY in 1935 and is at NY).

***balsamicola*, (*Meliola*)** Peck, Ann. Rep. New York State Mus. 34: 52. Pl. 1, Figs. 22-27. (for 1880) 1883.

Zukalia ? balsamicola (Peck) Sacc., Syll. Fung. 9: 432. 1891.

Dimerosporium balsamicola (Peck) Ellis & Everh., N. Amer. Pyrenomyc. p. 728. 1892, non Sacc. Ann. Mycol. 13: 115. 1915.

Dimeriella balsamicola (Peck) Petrak in Terrier, Bull. Soc. Bot. Suisse 57: 167. 1947.

Dimerium balsamicola (Peck) Shoemaker, Canad. J. Bot. 43: 632. 1965.

Type specimen (holotype): "living or languishing leaves of balsam fir, associated with *Peziza balsamicola*" now known to be on *Meliola* mycelium over leaves of *Abies balsamea*, Stony Clove, Catskill Mts., Greene Co., N. Y., Aug 1880, C. H. Peck. One gathering originally bearing the name *Peziza* (*Tapesia*) *bifructifera* Pk. and later changed to *P. balsamicola* Pk. was segregated into the types of *Peziza balsamicola* Pk. and *Meliola balsamicola* Pk.

This fungus has been studied and discussed by Hahn (1947), Farr (1963), and Shoemaker (1965). Barr agrees with the findings of the latter author, who transferred the species to *Dimerium*.

***banningiae*, (*Hypomyces*)** Peck (as *banningii*), Bot. Gaz. 4: 139. 1879.

Peckiella banningiae (Peck) Sacc., Syll. Fung. 9: 945. 1891.

Peckiella hymenii Peck, Bull. New York State Mus. 116: 28, 29. 1907.

Type specimen (holotype): on decaying fungi, apparently some *Lactarius*, Baltimore, Baltimore Co., Maryland, Aug 1878, M. E. Banning, #23.

The box at NYS labelled "*Hypomyces banningii* Peck, Baltimore, Maryland collected by Miss M. Banning, No. 23, 1878" now contains two parasitized agaric carpophores, each bearing a different species of *Hypomyces*. At one time these had been tied onto a card which subsequently had been cut into sections and placed in the box. When these sections are fitted together, it is clear that specimens of two species of *Hypomyces* were tied onto the card for comparison, probably by Miss Banning. In pencil (possible by Peck) are the names *Hypomyces banningii* (under specimen at left) ad *Hypomyces lactifluorum)* (under specimen at right). The card also has in inked handwriting (?Banning's) "no. 23 1878 this is the same as no. 3 of last year." Peck's brief description certainly refers to the specimen on the left side of card; ascospores were described as oblong fusiform, 30-37 × 4-5 μm. Rogerson's study indicates that the ascospores are simple, nonapiculate and minutely verrucose. Also a colored painting at NYS by Miss Banning of parasitized carpophores and drawings of four ascospores labelled as "*Hypomyces banningii* n. sp. plate 151" clearly indicates that the specimen on the left side of card refers to *H. banningiae*.

In a note accompanying her specimens, Banning writes to Peck "These two dried plants are the same as the drawing No. 3 which I sent you last season. . . . One plant was bright orange color deepened into red, the other white or dirty white with not so brown or perfect a pileus as that of last year." Peck has annotated this on the margin "*Hypomyces lactifluorum* Schw. as to the red. *Hypomyces banningii* Pk. as to the whitish one. They (*H. banningii* and *H. lactifluorum*) differ in color only and somewhat in the shape of the spores. . . ."

Seaver, Mycologia 2: 70, 71. 1910, accepted the species (as *Peckiella banningiae*) and cited as specimens examined, "Baltimore, Miss Banning (type)." But he described and illustrated the ascospores as "30-35 × 5-6 mic. becoming delicately roughed externally, with a distinct apiculus at each end, simple." Rogerson's study indicates that the second specimen is *Hypomyces lactifluorum* (Schweinitz:Fries) Tulasne, Ann. Sci. Nat. Bot. IV. 13: 11. 1860.

Apparently Seaver studied immature material of the specimen of *Hypomyces lactifluorum* which has apiculate, verrucose, two-celled ascospores; the ascospores of *Hypomyces banningiae* are not apiculate.

Hypomyces banningiae is accepted as a distinct species. It was later given another name, *Peckiella hymenii* Peck (see under that species). Another collection (F. S. Boughton, Pittsford, N. Y., Aug 1904) at NYS, identified by Peck as *H. banningiae*, proves to be *Hypomyces lateritius* (Fries) Tulasne, Ann. Sci. Nat. Bot. IV. 13: 11. 1860.

***bartholomaei*, (*Hypoxylon*)** Peck, Bull. New York State Mus. 150: 56. 1911.

Type specimen (holotype): on decorticated wood of *Alnus rubra*, Rolling Bay, Washington, 25 Aug 1909, E. Bartholomew, #4189 (also distributed as Ellis and Everhart's Fungi Columbiani #3332).

Miller (1961) recognized **Hypoxylon bartholomaei** as a distinct species.

***betulina*, (*Diatrype*)** Peck, Ann. Rep. New York State Mus. 25: 101, 102. Pl. 1, Figs. 27-31. (for 1871) 1873.

Diatrypella betulina (Peck) Sacc., Syll. Fung. 1: 208. 1882.

Type specimen (holotype): on branches of *Betula lutea*, Greig, Lewis Co., New York, Sept 1870, C. H. Peck (original gathering now in two different packets, one with a drawing and evidence of having been glued to a sheet has an annotation slip by K. Prasil which designates it as lectotype).

This is one of the small-spored species of *Diatrypella*, separated from *D. decorata* Nits. by the dull green interior of stroma surrounding the perithecia. Fig. 109.

***bicincta*, (*Valsa*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 26: 86. (for 1872) 1874 (*nomen nudum*); 29: 64. (for 1875) 1878.

Diaportha bicincta (Cooke & Peck) Sacc., Syll. Fung. 1: 622 1882.

Type specimen (isotype): on branches of *Juglans cinerea*, Greenbush, Rensselaer Co., New York, May 1871, C. H. Peck (according to Peck's notebooks a portion of this was sent to Cooke 24 Feb 1872 as #230).

According to Wehmeyer (1933) this is one of the synonyms of **Diaporthe spiculosa** (Alb. & Schw. ex Fr.) Nits.

***binoculata* var. *magnoliae-acuminatae*, (*Diaporthe*)** Peck ex Sacc., Syll. Fung. 11: 307. 1895.

Type specimen (holotype): on branches of *Magnolia acuminata*, Carrollton, Cattaraugus Co., New York, Sept 1890, C. H. Peck. Peck [Ann. Rep. New York State Mus. 44: 140 (reprint p. 28) (for 1890) 1891] indicated that his collection differed from the description of *Diaporthe binoculata* but he did not give it a varietal name. According to Wehmeyer (1933) the fungus does not have varietal difference from **Diaporthe binoculata** (Ellis) Sacc.

biuncinata, (Podosphaera) Cooke & Peck, J. Bot. II. 10: 11. 1872; Ann. Rep. New York State Mus. 25: 94, 95. (for 1871) 1873.

Type specimen (isotype): on leaves of *Hamamelis virginiana*, Sand Lake, Rensselaer Co., New York, 1871, C. H. Peck (according to Peck's notebooks a specimen was sent to Cooke 10 Nov 1871 as #144 and a further duplicate sent 13 May 1872 under the same number).

Salmon (1900) and Braun (1984a) recognized this as a valid species.

***boletinus*, (*Hypomyces*)** Peck, Bull. New York State Mus. 75; 15. 1904.

Hypomyces chrysospermus Tulasne var. *boletinus* (Peck) Maire, Ann. Mycol. 9: 300. 1911.

Apiocrea boletina (Peck) G. Arnold, Z. Pilzk. 37: 192. 1971.

Type specimen (holotype): on some unidentified decaying boletes, associated with *Sepedonium chrysospermum*, Lake Pleasant, Hamilton Co., New York, 14 Aug 1904, C. H. Peck.

This is typical **Hypomyces chrysospermus** Tulasne, Ann. Sci. Nat. Bot. IV. 13: 16. 1860.

***brevis*, (*Valsa*)** Peck, Bull. Torrey Bot. Club 22: 210, 211. 1895.

Enqizostoma breve (Peck) O. Kuntze, Rev. Gen. Pl. 3: 473. 1898.

Type specimen (holotype): on *Abies balsamea*, Labrador (location illegible), 10 Oct 1894, Waghorne.

The fungus is a form of **Leucostoma kinzei** (Fr.) Defago.

***brunnea*, (*Diatrype*)** Cooke & Peck in Day, Bull. Buffalo Soc. Nat. Sci. 4: 229. 1882 (*nomem nudum.*).

Specmem: on branches of *Quercus*, Sand Lake, Rensselaer Co., Oct., C. H. Peck. (A specimen labeled *Diatrype brunnea* by Cooke is at Kew (K) filed under *Valsaria quadrata*. According to Peck's notebooks, this specimen was sent 1 July 1871 as #55. The notes also state "Greenbush" as the locality.)

A description of *Diatrype brunnea* was never published. The name appeared along with *D. obesa* in Day's "The plants of Buffalo and its vicinity" as a synonym of *D. quadrata*: "2447. *D*[*iatrype*] *quadrata*, Schw. (*L.* [sic] *obesa* B. and C. *D. brunnea* C. and P.) Dead trunks and branches." Peck (Bull. New York State Mus. 131: 95. 1908) indicated that it was a "name" only. Saccardo (Syll. Fung. 1: 745. 1882) gave *D. quadrata* and *D. obesa* as synonyms of *Valsa-*

ria quadrata (Schw.) Sacc. However, Schweinitz's species is *Hypoxylon quadrata* (Schw.) Ellis & Everh. The only specimen at NYS bearing the name, *Diatrype brunnea*, is instead **Valsaria exasperans** (Gerard) Ellis & Everh.

caesariata, (*Sphaeria*) (*Villosae*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 60. (for 1875) 1878.
Lasiosphaeria caesariata (Cooke & Peck) Sacc., Syll. Fung. 2: 192. 1883.
Type specimen (isotype): on decaying wood, Portville, Cattaraugus Co., New York, Sept 1871, C. H. Peck (according to Peck's notebooks, a portion of this collection was sent to Cooke 1 Nov 1871 as #136).

The anamorphic state associated with and arising from ascomata of *Sphaeria caesariata* has caused considerable difficulty in the disposition of this species. The anamorph appeared to be a species of *Sporidesmium*, and could be identical with *S. socium* M. B. Ellis. Such a disposition offered no indication of the position of the teleomorph, however. *Sporidesmium socium* was transferred to *Endophragmiella* as *E. socia* (M. B. Ellis) S. J. Hughes (New Zealand J. Bot. 17: 153. 1979) and upon re-examination of a slide from Peck's specimen, the rhexolytic separation of conidia was quite obvious. The anamorph is indeed a species of *Endophragmiella* closely related to *E. socia*. Recent delimitation of *Phaeotrichosphaeria* Sivanesan (Trans. Brit. Mycol. Soc. 81: 313. 1983) finally provided a suitable disposition for *Sphaeria caesariata*. Sivanesan described the genus with one-celled or one-septate ascospores, and this species expands the concept for this character; other aspects of *P. caesariata* accord with *Phaeotrichosphaeria* as a member of the Lasiosphaeriaceae, rather than a relationship with *Trichosphaeria* and *Chaetosphaeria* as Sivanesan 1983) suggested. **Phaeotrichosphaeria caesariata** (Cooke & Peck) Barr, comb. nov Figs. 72-74.

Perithecia seated in thin blackish subiculum on surface of decorticated wood, scattered or grouped, globose conic, 220-275 μm diam, apex papillate; wall glabrous or bearing short conidiophores, surface shining black, in section reddish brown, ca. 20μm wide, firm, several layers of small cells. Asci 100-105 × 10-12 μm, unitunicate, clavate, short stipitate, apical annulus shallow, nonchitinoid, nonamyloid; paraphyses broad, with granular contents. Ascospores 28-32 × 5 μm, hyaline to light yellowish brown, short end cells hyaline, fusoid, straight or slightly curved, 7-septate, not constricted at septa, one globule per cell, wall smooth, overlapping biseriate in the ascus.

callicarpae, (*Diaporthe*) Peck, Bull. New York State Mus. 150: 53, 54. 1911.
Type specimen (holotype): on branches of *Sambucus callicarpa*, Rolling Bay, Washington, Aug 1909, E. Bartholomew #4146 (also distributed as Ellis & Everhart's Fungi Columbiani #3318).

Wehmeyer disposed of Peck's species in the synonymy of **Diaporthe sociabilis** Nits. var. **sambuci** (Ell. & Ev.) Wehm. (1933). He noted that the variety was close to *D. spiculosa* (Alb. & Schw. ex Fr.) Nits.

callista, (*Chilonectria*) (Bek. & Curt. in Ravenel) Peck in Day, Bull. Buffalo Soc. Nat. Sci. 4: 225. 1883.
Sphaeria callista Berk. & Curt. in Ravenel, Fungi Carol. 5: 67. 1860 (*nomen nudum*).
Cucurbitaria callista Berk. & Curt., Grevillea 4: 4. 1876.
Fracchiaea callista (berk. & Curt.) Sacc., Syll. Fung. 1: 94. 1882.

Neofracchiaea callista (Berk. & Curt.) Teng, Sinensia 9: 255. 1938.

In his notebook for 1874, Peck originally thought that two collections of a fungus on *Cornus alternifolia* (Buffalo, New York, G. W. Clinton and Sand Lake, New York, Peck) represented a new species of *Nectria*. Subsequently, he decided that they were the same as *Sphaeria callista*, apparently based on a comparison of the specimen, Ravenel, Fungi Carol. Fasc. 5, no. 67, at NYS. Peck (Ann. Rep. New York State Mus. 34: 58. 1881) reported a collection (on bark of mountain maple bush, *Acer spicatum*, Catskill Mountains, New York) as *Sphaeria callista* B. & R. and indicated that "this fungus should be referred to the genus *Chilonectria*." He made the transfer in Day's "The plants of Buffalo and its vicinity."

Five packets of the fungus collected by Peck are at NYS (Catskill Mts., host not indicated; Catskill Mts., on *Carpinus*; Catskill Mts., on *Carpinus caroliniana*; Albany, Albany Co., on *Cornus alternifolia*; and Sand Lake, Rensselaer Co., no host indicated). All contain the same fungus and were annotated, apparently by House, as *Fracchiaea callista*. Fitzpatrick (1924) indicated that *F. callista* should be excluded from *Fracchiaea* and placed in *Cryptosphaerella*. He did not make the transfer. Nannfeldt's revision (1975) of species in the Coronophorales resulted in the transfer of the species under discussion as **Nitschkia callista** (Berk. & Curt.) Nannf., Svensk Bot. Tidskr. 69: 309. 1975. He noted the apparent limitation of distribution of this species to eastern North America.

camphorati, (*Hypomyces*) Peck, Bull. New York State Mus. 105: 23. 1906.
Peckiella camphorati (Peck) Seaver, Mycologia 2: 68. 1910.
Type specimen (holotype): on the hymenium of *Lactarius camphoratus* Port Jefferson, Suffolk Co., New York, Aug 1905, C. H. Peck.

Hypomyces camphorati is a distinct species related to *H. lateritius* (Fr.) Tulasne.

canina, (*Sphaeria*) Peck, Ann. Rep. New York State Mus. 28: 78, 79. (for 1874) 1876.

Philocopra canina (Peck) Sacc., Syll. Fung. 1: 251. 1882.

Pleurage canina (Peck) O. Kuntze, Rev. Gen. Plant. 3: 505. 1898.

Type specimen (holotype): on dog dung, Bethlehem, Albany Co., New York, May 1874, C. H. Peck (now in two packets).

Nils Lundquist examined the packet marked "isotype" by Homer House containing four portions of the substrate glued to cards; he marked one of these as isotype, the other three as isolectotypes and annotated the material as being *Ryparobius cookei* (cr.) Boud. The species belongs in **Thelebolus** Tode ex. Fr. Emend. Kimbrough.

caryae, (Cryptospora) Peck, Ann. Rep. New York State Mus. 38: 106. Pl. 2, Figs. 28-31. (for 1884) 1885.

Ophiovalsa carvae (Peck) J. N. Kapoor & S. P. Lal, Indian Phytopath. 35(1): 144. 1982.

Type specimen (holotype): on *Carya alba*, Knowersville, Albany Co., New York, May 1884, C. H. Peck.

Wehmeyer based the genus *Phragmodiaporthe* on this species: **Phragmodiaporthe caryae** (Peck) Wehm., Mycologia 33: 55. 1941.

cassandrae, (Venturia) Peck, Ann. Rep. New York State Mus. 38: 104. Pl. 3, Figs. 11-14. (for 18840 1885.

Gibbera cassandrae (Peck) Barr, Canad. J. Bot. 39; 313. 1961.

Type specimen (holotype): on leaves of *Chamaedaphne* (*Cassandra*) *calyculata*, Caroga, Fulton Co., New York, July 1884, C. H. Peck (original label bears collection number 59). Much earlier Peck used the name *Venturia cassandrae* for a specimen sent to Cooke as #32. Cooke changed the name to *V. pulchella* Cooke & Peck before publication so that the 1885 publication is valid.

ceanothi, (Microsphaera) (Schw.) Peck, (as *caeanothi*). Ann. Rep. New York State Mus. 39: 50. (for 1885) 1887.

Erysiphe ceanothi Schw., Trans. Amer. Philos. Soc. II. 4: 269. 1832.

Peck made two collections, one on leaves and one on fruits of *Ceanothus americanus*, New Scotland, Albany, Co., New York.

Salmon (1900) considered this a synonym of *Microsphaera alni* (Wallr.) Salmon var. *alni*. The earlier epithet is **M. penicillata** (Wallr.:Fr.) Lév. var. **penicillata** according to W. B. Cooke (1952).

ceanothina, (Sphaeria) (*Obtectae*) Peck, Ann. Rep. New York State Mus. 29: 62. (for 1875) 1878.

Physalospora ceanothina (Peck) Sacc., Syll. Fung. 1: 441. 1882.

Type specimen (holotype): on branches of *Ceanothus americanus*, Center (Karner), Albany Co., New York, May 1875, C. H. Peck.

In the Calosphaeriaceae, the septation of ascospores seems to be variable and of specific value only in several genera. *Sphaeria ceanothina* has the features of ascomata found in *Jattaea*, and is now **Jattaea ceanothina** (Peck) Barr, Mycologia 77: 559. 1985. Figs. 63-66.

Additional collections of *J. ceanothina* in NYS are: on *Ceanothus americanus*, Albany, Albany Co., 15 Nov 1915, H. D. House (as *Metasphaeria ceanothina*); on *Cornus*, Bethlehem, Albany Co., New York, C. H. Peck.

celastri, (Nectria) (Schw.) Peck, Ann. Rep. New York State Mus. 26: 84. (for 1872) 1874.

Sphaeria celastri Schw. in Fries, Elench. Fung. 2: 81. 1828; Trans. Amer. Philos. Soc. II. 4: 205. 1832.

Cucurbitaria celastri (Schw.) O. Kuntze, Rev. Gen. Pl. 3: 460. 1898.

Under the name *Nectria celastri* Schw., Peck cited a collection from dead stems of *Celastrus scandens*, Greenbush, Rensselaer Co., New York, May 1872. He did not mention the basionym, *Sphaeria celastri*. No evidence at NYS could be found to indicate that he had seen material of *Sphaeria celastri* Schw. Nevertheless Peck's use of the name has been interpreted (Saccardo, Syll. Fung. 2: 481. 1883) as a transfer into the genus *Nectria*. Two collections made by Peck and labelled as *Nectria celastri* are at NYS. One (Greenbush, New York) is labelled "*Nectria celastri* (Schw.) Peck (*Sphaeria celastri* Schw.)"; the other (Greenbush, on *Celastrus scandens*, June) is labelled "*Nectria celastri* (Schw.) Peck (*Sphaeria* Schw.)." Both of these collections are *Nectria cinnabarina* (Tode:Fries) Fries, Summa Veg. Scand. 2: 388. 1849. Seaver (1909) indicated that "type or cotype material of *Sphaeria celastri* was examined and that it was *Creonectria purpurea* (L.) Seaver," which is **Nectria cinnabarina**.

chimaphilae, (Sphaerella) Peck, Ann. Rep. New York State Mus. 47: 24. (for 1893) Dec. 1894.

Sphaerella chimaphilina Peck in Sacc., Syll. Fung. 11: 297. 1895.

Type specimen (holotype): on leaves of *Chimaphila umbellata*, Cooperstown Junction, Otsego Co., New York, June 1893, C. H. Peck. This specimen could not be located.

This species was described earlier in 1894 by Ellis and Everhart. Parmelee (1958) described and discussed the species, and included Peck's name as a synonym of *Mycosphaerella chimaphilae* (Ell. & Everh.) v. Hohnel. B. Eriksson (1974) validated the older name *Mycosphaerella pyrolae* (Ehrenb.:Fr.) B. Eriksson, based upon a Friesian collection. Thus, *Sphaerella chimaphilae* Peck as well as *Mycosphaerella chimaphilae* (Ell. & Everh.) v. Hohnel are synonyms of the earlier **Mycosphaerella pyrolae**.

***chromosperma*, (*Hypocrea*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 56. (for 1875) 1878.

Type specimens (syntypes): on decaying wood, Croghan, Lewis Co., New York, C. H. Peck; another packet with same data plus "September"; a third packet, on dead hemlock, Felt House, Croghan, Lewis Co., New York, Sept 1872, C. H. Peck.

In the type description three localities were given: "Buffalo, Clinton; Greenbush and Croghan. July to September." Only the Croghan collections given above can be found at NYS. The first two of these appear to be portions of one collection; the stromata are similar in appearance; both are immature with ascospores not fully developed. The ascospores are given in color suggesting an alliance with the *Hypocrea gelatinosa* complex. The third packet contains a different *Hypocrea* with hyaline ascospores, probably near *H. rufa* (Pers.:Fr.) Fr. Seaver (1910) placed *Hypocrea chromosperma* as a doubtful synonym of *Chromocrea gelatinosa* (Tode:Fr.) Seaver; he did not study the NYS or K material. For the time being we are maintaining **Hypocrea chromosperma** as a distinct species. (Peck's notebooks indicate that the G. W. Clinton collection was sent to Cooke 21 Feb 1872 as #210 *Hypocrea*. The specimen was located at Kew together with a drawing of an ascus.)

***cinctula*, (*Valsa*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 59. Pl. 2, Figs. 21-24. (for 1875) 1878.

Cryptospora cinctula (Cooke & Peck) Sacc., Syll. Fung. 2: 363. 1883.

Winterella cinctula (Cooke & Peck) O. Kuntze, Rev. Gen. Pl. 1: 34. 1891.

Ophiovalsa cinctula (Cooke & Peck) Petrak, Sydowia 19: 274. 1966.

Type specimen (isotype): on branches of *Castanea dentata*, Guilderland, Albany Co., New York, May 1871, C. H. Peck (portion sent to Cooke 10 April 1872 as #272).

circinata, (Uncinula) Cooke, & Peck, J. Bot. II. 10: 12. 1872; Ann. Rep. New York State Mus. 25:96. (for 1871) 1873.

Type specimen (isolectotype): on leaves of *Acer spicatum*, Watkins, Schuyler Co., New York, Sept 1871, C. H. Peck. This collection is described in Peck's notebooks as *U. bicornis* Lév. A portion of this specimen was sent to Cooke 14 Nov 1871 as #158; (syntype): on *Acer*, Carolina, Ravenel, #1884.

Two collections were cited in the protologue. Since the collection at NYS from Watkins, New York, contains Peck's drawings and notes, this is designated the isolectotype; the lectotype would be at K. In the Report for 1871 published in 1873 Peck cited the collection from Watkins as well as one on *Acer rubrum* from Greenbush, Rensselaer Co., New York. This latter collection has no type status since it was not mentioned in the first publication of the species.

Salmon (1900) recognized this as a valid species of *Uncinula*.

***citri*, (*Polymorphia*)** unpublished genus & species in Peck herbarium.

A small specimen of a pyrenomycete on *Citrus aurantium* from Florida was sent to Peck by Thomas Taylor, May 1884. Peck briefly described the fungus on the bottom of Taylor's letter and gave it the above name. There is no evidence that Peck made any effort to publish this name. The specimen has been examined by Anna Jenkins in 1937 and more recently by A. Y. Rossman who annotated it as **Podonectria coccicola** (Ellis & Everh.) Petch.

***clavariina*, (*Sphaeria*)** Peck, Ann. Rep. New York State Mus. 32: 51. (for 1878) 1880.

Type specimen (holotype): on *Clavaria cristata*, Sand Lake, Rensselaer Co., New York, Aug 1878, C. H. Peck.

The name is a synonym of **Helminthosphaeria clavariae** (Tul.) Fuckel. Peck later annotated his type specimen to that effect.

***clavisporum*, (*Hysterium*)** Cooke & Peck in Cooke, Bull. Buffalo Soc. Nat. Sci. 3: 34. 1875, Ann. Rep. New York State Mus. 28: 69. (for 1874) 1876.

Dothidea clavispora (Cooke & Peck) Peck, Ann. Rep. New York State Mus. 29: 63. (for 1875) 1878.

Rhopographus clavisporum (Cooke & Peck) Sacc., Syll. Fung. 2: 648. 1883.

Bruneaudia clavispora (Cooke & Peck) O. Kuntze, Rev. Gen. Pl. 3: 447. 1898.

Calospora clavispora (Cooke & Peck) Theiss. & Sydow, Ann. Mycol. 13: 428. 1915.

Type specimen (isotype): on *Phragmites communis*, Tyre, Seneca Co., New York, Sept 1871, C. H. Peck (now in two packets). According to Peck's notebooks a portion of this collection was sent to Cooke 11 Oct 1871 as #105 and a duplicate was sent to Gerard 17 Feb 1875.

The fungus forms elongate ascomata in which several locules develop. The structure of ascomata, asci, and ascospores conforms with Hedjaroude's (1969) emended characterization of *Phaeosphaeria*. In this genus the species belongs to the "group of *P. nigrans*" and is most closely related to *P. typhicola* (Karst.) Hedjaroude which also occurs on *Phragmites*. *Phaeosphaeria typhicola* has small globose ascomata and larger ascospores which are less asymmetric than those of *P. clavispora*.

Phaeosphaeria clavispora (Cooke & Peck) Barr, comb. nov. Figs. 26, 27.

Ascomata elliptic, ± applanate in vertical section, 500-1000 μm or longer, 200-300 μm wide, 150-250 μm high, immersed-erumpent; locules 120 μm diam, in a single row and separated by rather thin walls, recognizable mainly by the position of asci, opening by short apical pore; wall of large dark brown cells, thick at lower sides, up to 60 μm wide, above 26-40 μm wide, base thinner. Asci 88-105 × 22-25 μm, bitunicate, clavate, base foot-shaped, few (2-4) in section through locule; pseudoparaphyses broad, cellular. Ascospores 31-39 × 7.5-10 μm, yellowish brown to dark brown, narrowly obovate and strongly tapered to base, 9-11 septate, primary septum supramedian, cell above this (3rd or 4th) enlarged, somewhat constricted at primary septum, with one globule per cell, wall thick, dark brown, surrounded by gel coat 3-3.5 μm wide, overlapping biseriate in the ascus.

Leptosphaeria clavicarpa Ellis & Everh., J. Mycol. 1:43. 1885 [*Heptameria clavicarpa*] (Ellis & Everh.) Cooke, Grevillea 18: 32. 1889] is an additional synonym of *P. clavispora*.

clavulata, **(*Torrubia*)** (Schw.) Peck, Ann. Rep. New York State Mus. 28: 70. (for 1874) 1876.

Sphaeria clavulata Schw., Trans. Amer. Philos. Soc. II. 4: 188. 1832.

Cordyceps clavulata (Schw.) Ellis & Everh., N. Amer. Pyrenomyc. p. 61. 1892.

Mains (1958) recognized the species as *Cordyceps clavulata*. He did not cite any specimens from NYS. Under the name *Torrubia clavulata* Schw., Peck (Rep. 28: 70) discussed a single collection (on dead scale insects on black-ash branches, *Fraxinus sambucifolia*, Lake Pleasant, Hamilton Co., New York, Aug, probably 1874) and indicated that it was *Sphaeria clavulata* Schw. which he transferred into *Torrubia*. Another collection at NYS (on scale insect on *Ilex verticillata*, Root, Montgomery Co., New York, June 1878, C. H. Peck) also is labelled *Torrubia clavulata* Schw. Both collections are **Cordyceps clavulata**.

clintonii, **(*Sphaeria*)** (*Villosae*) Peck, Ann. Rep. New York State Mus. 30: 65. (for 1876) 1878.

Acanthostigma clintonii (Peck) Sacc., Syll. Fung. 2: 210. 1883.

Type specimen (holotype): on decaying wood, Buffalo, Erie Co., New York, Nov 1876, G. W. Clinton.

The type description gives the locality as Alden, which is less than 20 miles east of Buffalo; the original label has "Buffalo." A second collection in NYS labelled *A. clintonii* on *Acer* wood, Knowersville, Albany Co., N. Y., July, C. H. Peck, is instead *A. scopula* (Cooke & Peck) Peck (q.v.).

The genus *Acanthostigma* de Not. presently shelters a diverse assemblage of species. The brief description of the type species, *A. perpusillum* de Not., indicates that asci are aparaphysate, and the genus may be sphaeriaceous. *Acanthostigma clintonii* is a loculoascomycete, **Tubeufia clintonii** (Peck) Barr, Mycotaxon 12: 163. 1980.

clintonii, (Uncinula) Peck, Trans. Albany Inst. 7:216. 1872; Ann. Rep. New York State Mus. 25: 96, 97. (for 1871) 1873.

Type specimen (lectotype): on leaves of *Tilia americana*, Buffalo, Erie Co., New York, G. W. Clinton; (syntype) Watkins, Schuyler Co., New York, Oct, C. H. Peck.

Salmon (1900) recognized this as a valid species of *Uncinula*.

clintonii, **(*Venturia*)** Peck, Ann. Rep. New York State Mus. 28: 82. (for 1874) 1876.

Type specimen (holotype): on leaves of *Cornus rugosa* (*C. circinata*), Buffalo, Erie Co., New York, May 1874, G. W. Clinton.

Peck's name and the fungus are synonyms of **Venturia systema-solare** (Fuckel) Winter (Müller 1958, Barr 1968).

colorata, **(*Sphaerella*)** Peck, Ann. Rep. New York State Mus. 29: 62, 63. Pl. 2, Figs. 15-17. (for 1875) 1878.

Mycosphaerella colorata (Peck) House, Bull. New York State Mus. 233-234: 26. 1921.

Type specimen (holotype): on spotted leaves of *Kalmia angustifolia*, Center (= Karner), Albany Co., New York, June-July 1875, C. H. Peck (now in two packets).

compacta, **(*Venturia*)** Peck, Ann. Rep. New York State Mus. 25:106. (for 1871) 1873.

Gibbera compacta (Peck) Shear, Techn. Bull. U.S.D.A. 258: 13. 1931.

Pyrenobotrys compacta (Peck) B. Erikss. Svensk. Bot. Tidskr. 68: 224. 1974.

Type specimen (holotype): on leaves of *Vaccinium macrocarpon*, Sand Lake, Rensselaer Co., New York, June 1871, C. H. Peck (according to correspondence at NYS a portion of the type was sent to BPI by Homer House in 1945).

Barr (1968) could not separate *Venturia compacta* from *Stigmatea conferta* (Fr.) Fr., and synonymized Peck's name. However, B. Eriksson (1974) pointed out significant differences between the two species. She also recognized that *Pyrenobotrys* must be utilized in place of *Stigmatea*. Fig. 111.

conigena, **(*Sphaerella*)** Peck, Ann. Rep. New York State Mus. 33: 34. (for 1879) 1883.

Sphaerella conicola Peck in Sacc., Syll. Fung. Addit. 1-4: 75. 1886, non *Sphaerella conigena* Peck in Sacc., Syll. Fung. 9: 649. 1891.

Cucurbitaria conigena (Peck) O. Kuntze, Rev. Gen. Pl. 3: 461. 1898.

Mycosphaerella conigena (Peck) House, Bull. New York State Mus. 233-234: 26. 1921.

Scirrhia conigena (Peck) Barr, Contr. Univ. Michigan Herb. 9: 566. 1972.

Type specimen (holotype): on cones of arbor vitae (*Thuja occidentalis*), Helderberg Mts., New York, July 1879, C. H. Peck (original now housed in two separate packets and according to correspondence at NYS, a portion of the type was sent to NY by Homer House in 1935 and is at NY). Drawings attributed to Peck comparing *Sphaerella conicola* Peck and *Sphaerella conigena* Peck are also at NY (from the Ellis herbarum).

conigena, (*Sphaerella*) Peck, Ann. Rep. New York State Mus. 38: 104. (for 1884) 1885. (non *Sphaerella conigena* 1883 above.)

Sphaerella peckii Sacc., Syll. Fung. 9: 649. 1891, non Speg. 1880.

Mycosphaerella peckii Lindau in Engler & Prantl, Nat. Pflanzenfam. 1: 425. 1897.

Sphaerella tsugae House, Bull. New York State Mus. 205, 206: 40. 1919.

Mycosphaerella tsugae (House) House, Bull. New York State Mus. 233-234: 31. 1921.

Delphinella tsugae (House) Barr, Contr. Univ. Michigan Herb. 9: 563. 1972.

Type specimen (holotype): on cones of *Tsuga canadensis*, Knowersville, Helderberg Mountains, Albany Co., New York, May 1884, C. H. Peck. (Part sent to Ellis and is now at NY.)

Since *Sphaerella peckii* Spegazzini 1880 has never been transferred to *Mycosphaerella*, *Mycosphaerella peckii* Lindau 1897 is a valid name in *Mycosphaerella* (Article 72, International Code of Botanical Literature, 1972) and is earlier than *Sphaerella tsugae* House 1919. The combination **Delphinella peckii** (Lindau) Barr, comb. nov. is proposed (Basionym: *Mycosphaerella peckii* Lindau in Engler and Prantl, Nat. Pflanzenfam. 1: 425. 1897).

contortum (Chaetomium) Peck, Ann. Rep. New York State Mus. 49: 24. (for 1895) 1897.

Type specimen (holotype): on bulbs of *Lilium longiflorum*, Woodside, Queens Co., New York, March 1895, F. C. Stewart. A letter from Stewart to Peck states "The owner says that the bulbs were sold to him as coming direct from Japan...."

Ames (1963) accepted this as a distinct species.

corallorhizae, (*Leptosphaeria*) Peck, Ann. Rep. New York State Mus. 38: 105. Pl. 2, Figs. 20-23. (for 1884) 1885.

Type specimen (holotype): on stalks of *Corallorhiza multiflora*, Caroga, Fulton Co., New York, July 1884, C. H. Peck.

The fungus is a species of *Phaeosphaeria*, most closely related to *P. eustoma* (Fuckel.) Holm but differing from it in narrow ascospores and in the host plant.

Phaeosphaeria corallorhizae (Peck) Barr, comb. nov. Figs. 28, 29.

Ascomata immersed, globose depressed, 105-250 μm diam, apex short papillate; wall thin, a few hyphae scattered over surface. Asci 48-65 × 6-7 μm, bitunicate, cylindric clavate, base foot-shaped; pseudoparaphyses present. Ascospores 16-20 × 2.5-3.5 μm, yellowish, fusoid, 3-septate, constricted at primary median septum, cell above slightly enlarged, contents minutely guttulate, wall smooth, overlapping biseriate in the ascus.

Shoemaker (1985) redescribed and illustrated *L. corallorhizae* as a species of *Leptosphaeria* related to *L. purpurea* Rehm. The Narrow peridium is composed of two to three rows of thick-walled cells and at least some of the collections ascribed to the species bear globose terminal appendages on the ascospores.

corniformis var. *irregularis*, (*Xylaria*) Peck, Ann. Rep. New York State Mus. 28: 87. (for 1874) 1876.

Specimen: Lowville, Lewis Co., New York, Aug 1872, C. H. Peck (2 packets). No type was designated at the time of publication but the Lowville collection is the only one labelled var. *irregularis* in the Peck herbarium. A portion of this collection was sent to M. C. Cooke 28 Jan 1874 as #339.

This variety is based on irregular shape of the stromata, and is scarcely distinct from **X. corniformis** Mont. The microscopic characters of the two are identical.

cornina, (*Valsa*) Peck, Ann. Rep. New York State Mus. 38: 102, 103. (for 1884) 1885.

Type specimen (holotype): on branches of *Cornus paniculata*, Albany, Albany Co., New York, April 1884, C. H. Peck. There is an apparent conflict in the type locality information for this species. The protologue gives Albany as the locality whereas on two packets which otherwise agree with the type information one gives Kenwood and the other gives Bethlehem as the locality. The specimen labelled Kenwood on the outer label has a portion of the original newsprint packet inside which states "Side Hill, South of Susq. R. R. Bridge No. 2 near A.(lbany)." This location is near the village of Kenwood in the town of Bethlehem on the Albany town border. This specimen further agrees with Peck's notebook by first being annotated "*Valsa irregularis*" then reannotated "*Valsa cornina*." The Bethlehem packet appears to contain a portion of the same collection. No packet labelled Albany could be located and it seems likely that Peck was referring to this collection which was made on the bank of the small river separating the two towns.

This fungus belongs in **Romellia** and is **R. cornina** (Peck) Barr, Mycologia 77: 560. 1985. Fig. 66.

coryli var. ***spiralis***, (***Sphaeria***) Peck, Ann. Rep. New York State Mus. 34: 57. (for 1880) 1883.

Mamianiella coryli var. **spiralis** (Peck) Barr, Mycol. Mem. 7: 87. 1978. Figs. 98-100.

Specimen: on leaves of *Corylus rostrata* (*C. cornuta*), Osceola, Lewis Co., New York, Aug probably 1875, C. H. Peck (now in two packets).

This variety is similar to the typical variety microscopically; the ostioles are spirally twisted. Var. *spiralis* is widespread in northeastern and central North America on *Corylus cornuta* and *C. americana*, while var. *coryli* is European on *C. avellanea* and midwestern to western North American on *C. americana*, *c. cornuta*, and *C. californica*.

coulteri, (***Sphaeria***) Peck in Hayden, U. S. Geol. Survey Territ. Rep. 6: 792. 1873.

Neopeckia coulteri (Peck) Sacc. in Peck, Bull. Torrey Bot. Club 10: 127, 128. 1883.

Enchnosphaeria coulteri (Peck) Sacc., Syll. Fung. 2: 207. 1883.

Lasiosphaeria coulteri (Peck) Ellis & Everh., N. Amer. Pyrenomyc. p. 417. 1892.

Herpotrichia coulteri (Peck) Bose, Phytopath. Z. 41: 195. 1961.

Type specimen: not located at NYS; on *Pinus*, near Yellowstone Lake, Wyoming Territory, Prof. J. M. Coulter. A portion of the isotype labelled "Yellowstone (Coulter) P. A. Saccardo" is in the *N.coulteri* folder in UPS.

This species is the basis for *Neopeckia* Sacc. Barr (1984) cannot acquiesce with synonymizing the genus with *Herpotrichia* as Bose (1961), Müller and von Arx (1962) and Sivanesan (1971) have done. Ascomatal structure, cylindrical asci, and reddish brown, ellipsoid ascospores all differ from these structures in *Herpotrichia* s. str. Additional synonyms of the species are: *Lasiosphaeria acicola* Cooke, Grevillea 8: 87. 1880; *Amphisphaeria* ? *acicola* (Cooke) Sacc., Syll. Fung. 1: 727. 1882.

cubense, (***Hysterium***) Peck, Bull. New York State Mus. 157: 48. 1912.

Type specimen (holotype): on fallen branches, Nazarene, Cuba, 23 Sept 1904, C. F. Baker, #1925.

The name and specimen are synonymous with **Rhytidhysteron rufulum** (Spreng.: Fr.) Petrak. In the type description, ascospores are given as 30-40 × 12-16 μm, however, Barr's measurements of ascospores are 20-25 × 7-9 μm. There is no possibility of confusing this with any other fungus as it is the only one on the branches in the type collection.

curreyi var. ***americana***, (***Massariella***) Peck, Ann. Rep. New York State Mus. 47: 24. (for 1893) 1894.

Type specimen (holotype): on branches of *Tilia americana*, Selkirk, Albany Co., New York, June 1893, C. H. Peck.

Barr cannot find sufficient difference to maintain this collection as a variety. The earliest epithet and correct generic disposition are: **Splanchnonema ampullaceum** (Pers.: Fr.) Shoemaker & Leclair, Canad. J. Bot. 53: 1570. 1970.

curvicolla, (***Sphaeria***) (*Caulicolae*) Peck, Ann. Rep. New York State Mus. 31: 50, 51. (for 1877) 1879.

Gnomoniella curvicolla (Peck) Sacc., Syll. Fung. 1: 417. 1882.

Eutypa curvicolla (Peck) Barr, Mycol. Mem. 7: 20. 1978.

Type specimen (holotype): on stalks of *Polygonella articulatum*, Center (= Karner), Albany Co., New York, Oct 1877, C. H. Peck.

A preferred disposition for this fungus is in the Calosphaeriales as **Jattaea curvicolla** (Peck) Barr, Mycologia 77: 558. 1985. Figs. 81-83.

curviseta, (***Venturia***) Peck, Ann. Rep. New York State Mus. 35: 145. (for 1881) 1884.

Antennularia curviseta (Peck) Barr, Canad. J. Bot. 46: 848. 1968.

Protoventuria curviseta (Peck) Barr, Canad. J. Bot. 49: 1960. 1971.

Type specimen (holotype): on leaves of *Nemopanthus mucronatus*, Center (= Karner), Albany Co., New York, May 1874, C. H. Peck. Fig. 112.

cylindrospora, (***Diaporthe***) Peck, Ann. Rep. New York State Mus. 38: 104. (for 1884) 1885.

Type specimen (holotype): on branches of *Prunus pensylvanica*, Aiden Lair, Adirondack Mts., Essex Co., New York, June 1884, C. H. Peck.

According to Wehmeyer (1933) this is a synonym of **Diaporthe prunicola** (Peck) Wehm.

cypripedii, (***Sphaerella***) Peck, Ann. Rep. New York State Mus. 51: 296. (for 1897) 1898.

Mycosphaerella cypripedii (Peck) House, Bull. New York State Mus. 233-234: 27. 1921.

Type specimen (holotype): on spotted leaves of hothouse grown *Cypripedium insigne* (= *Paphiopetalum insigne*), Bay Ridge, Long Island, Kings Co., New York, Oct 26, 1896, F. C. Stewart.

dalibardae, (**Dothidea**) Peck, Ann. Rep. New York State Mus. 27: 109. Pl. 1, Figs. 7-9. (for 1873) 1875.

Phyllachora dalibardae (Peck) Sacc., Syll. Fung. 2: 600. 1883.

Type specimen (holotype): on leaves of *Dalibarda repens*, Forestburgh, Sullivan Co., New York, Sept 1873, C. H. Peck. (Correspondence at NYS indicates that a portion of this collection was sent to NY in 1935 and is at NY.)

dasylirii, (**Dothidea**) Peck, Bot. Gaz. 7: 57. 1882.

Phyllachora dasylirii (Peck) Sacc., Syll. Fung. 2: 606. 1883.

Botryosphaeria dasylirii (Peck) Theiss. & Syd., Ann. Mycol. 13: 663. 1915.

Type specimen (holotype): on leaves of *Dasylirion*, probably *D. wheeleri*, Arizona, May 1881, C. G. Pringle, #64.

Botryosphaeria dasylirii appears to be closely related to *B. festucae* (Lib.) von Arx & Muller, on grasses and sedges, but differs in ascomata that are grown together to form an elongate stroma containing several small locules. Von Arx and Muller (1954) relegated *B. dasylirii* to synonymy with *B. quercuum* (Schw.) Sacc., which may have separate ascomata or several-loculate stromata. Shoemaker (1965) discussed some aspects of this composite species and illustrated both ascospores and conidia for *B. quercuum*. Although the conidial state of *B. dasylirii* is not known, the nearly equilateral ascospores differ conspicuously from the inequilateral ascospores of *B. quercuum* and *B. dasylirii* is again recognized as a separate species.

deformatum, (**Cenangium**) Peck, Ann. Rep. New York State Mus. 28: 68. (for 1874) 1876.

Cenangella deformata (Peck) Sacc., Syll. Fung. 8: 593. 1889.

Phaeangiella deformata (Peck) Sacc. & D. Sacc., Syll. Fung. 18: 128. 1906.

Karschia deformata (Peck) Peck, Bull. New York State Mus. 137: 117. 1909.

Dermatella deformata (Peck) Seaver, North American Cup Fungi (Inoperculates), p. 313. 1951.

Type specimen (holotype): on *Juniperus*, Greenbush, Rensselaer Co., New York, C. H. Peck. Portions of this collection were distributed to CUP-D, BPI and NY, and is at NY.

This fungus is identical with **Holmiella sabina** (de Not.) Petrini, Samuels & Müller, Rep. Swiss Bot. Soc. 89: 84. 1979, as Pirozynski and Reid (1966) observed (as *Eutryblidiella sabina*).

densissima, (**Microsphaera**) (Schw.) Cooke & Peck, J. Bot. II. 10: 171. 1872.

Erysiphe densissima Schw., Trans. Amer. Philos. Soc. II 4: 269. 1832.

Salmon (1900) synonymized the species with *Microsphaera alni* (Wallr.) Salmon; the earlier epithet is **M. penicillata** (Wallr.: Fr.) Lev. var. **penicillata** (W. B. Cooke 1952). Peck had collections from Saratoga, Saratoga Co., New York, 1872, from Poughkeepsie, Dutchess Co., New York (Gerard), and from Portage, Livingston Co., New York, (Clinton) all on *Quercus*.

depressa, (**Pyrenophora**) Peck, Bull. Torrey Bot. Club 11: 28. 1884.

Type specimen (holotype): dead stalks of *Arabis*, California, 1883, M. E. Jones. The outer label for the type packet states "Utah" in Homer House's handwriting but this is apparently in error as the inner packet and notebooks state California.

Wehmeyer (1961) included the species among the synonyms of *Platyspora permunda* (Cooke) Wehm. The genus *Comoclathris* Clements predates *Platyspora* and the species is **Comoclathris permunda** (Cooke) Müller, Beitr. Kryptogamenfl.Schweiz 15(1): 66. 1977.

depressa, (**Sphaerella**) Peck, Ann. Rep. New York State Mus. 33:34 (for 1879) 1883.

Laestadia depressa (Peck) Berl. & Vogl., Syll. Fung. Addit. 1-4: 61. 1886; Syll. Fung. 9: 578. 1891.

Mycosphaerella depressa (Peck) House, Bull. New York State Mus. 233-234: 27. 1921.

Guignardia depressa (Peck) Dearness & House, Bull. New York State Mus. 266: 73. 1925.

Type specimen (holotype): on dead stalks of *Lactuca*, Center (= Karner), Albany Co., New York, May 1879, C. H. Peck (the host named as *Mulgedium* in description). Peck's original herbarium label states *Laestadia epilobii* var. *lactucae* Peck but this name was changed before publication.

Asci of this fungus are unitunicate, the apical annulus giving an amyloid reaction. The fungus is now termed **Hyponectria depressa** (Peck) Barr, Mycologia 69: 961. 1977. Figs. 75-77 illustrate the species.

desmodii, (**Sphaeria**) Peck, Bull. Buffalo Soc. Nat. Sci. 1: 72. 1873.

Diaporthe desmodii (Peck) Sacc., Syll. Fung. 1: 691. 1882.

Type specimen (holotype): on stalks of *Desmodium*, Garrisons, Putnam Co., New York, June 1870, C. H. Peck.

This is one of the many synonyms of **Diaporthe arctii** (Lasch) Nits., according to Wehmeyer (1933).

diffusa, (**Microsphaera**) Cooke & Peck, J. Bot. II. 10: 13. 1872; Ann. Rep. New York State Mus. 25: 95. (for 1871) 1873.

Type specimen (isotype): on leaves of *Desmodium canadense*, Albany, Albany Co., New York, Sept-Oct 1871, C. H. Peck (now in two packets at NYS).

Salmon (1900) recognized **Microsphaera diffusa** as a distinct species. Four duplicates are now at K, one of which is marked #152 and was sent to Cooke 10 Nov 1871. Records at NYS show that a portion was sent to NY in 1935 and is at NY.

digitata var. americana, (Xylaria) Peck, Ann. Rep. New York State Mus. 31: 59, 60. (for 1877) 1879.

Type specimen (holotype): on prostrate trunks of *Acer saccharinum*, (now *A. saccharum*) Adirondack Mts., New York, Sept 1872, C. H. Peck.

The variety was described with ascospores shorter than in *Xylaria digitata* var. *digitata*. No type collection was designated at the time of publication but the above collection in the Peck herbarium is marked "var. *americana*" and is presumed to be the type.

digitata var. **tenuis**, (*Xylaria*) Peck, Ann. Rep. New York State Mus. 50: 133. (for 1896) 1897.

Type specimen (holotype): on *Acer saccharinum* (now *A. saccharum*), Piseco, Adirondack Mts., Hamilton Co., New York, Sept, C. H. Peck.

In this variety the ascospores are similar to those of **Xylaria digitata** var. **digitata**, but the stromata are slender; probably only a variant of the species. No type collection was designated at the time of publication but the above collection in the Peck herbarium is marked "var. *tenuis*" and is presumed to be the type.

discoidea, (*Diatrype*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 28: 71. (for 1874) 1876.

Diatrypella discoidea (Cooke & Peck) Sacc., Syll. Fung. 1: 207. 1882, as *Diatrypella discoidea* Cooke & Peck.

Type specimen (isotype): on branches of *Betula populifolia*, Center (= Karner), Albany Co., New York., Oct 1874, C. H. Peck. (A portion of this collection was sent to Cooke 22 Dec 1874 as "#355 *Diatrype decorata* Nits.".) The NYS packet has been annotated as lectotype by K. Prasil 10 Oct 1980, but the authors have not been able to confirm that this has been published.

Petrak (1940) recognized that the American fungus was identical with the European **Diatrypella decorata** Nits.

eccentrica, (*Sphaeria*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 25: 105. (for 1871) 1873.

Gnomoniella eccentrica (Cooke & Peck) Sacc., Syll. Fung. 1: 418. 1882.

Type specimen (lectotype): on stalks of *Polygonum*, Portville, Cattaraugus Co., New York, Sept 1871, C. H. Peck; (syntype): on dead stems of *Polygonum*, Albany, Albany Co., New York, June 1871, C. H. Peck (sent to Cooke 5 June 1871 as #33 *Sphaeria curvirostris*).

The collection from Portville has mature spores; the Albany collection is immature. This material is identical with the European **Plagiostoma devexum** (Desm.) Fuckel (Barr, 1978). The mature specimen, unfortunately, was not the collection seen by Cooke when he proposed the name.

effusum, (**Melogramma**) Peck, Ann. Rep. New York State Mus. 47: 152 (reprint p. 26). (for 1893) 1894.

Type specimen (holotype): on decaying wood (elm?), Ottawa, Ontario, Canada, 6 Sept 1892, J.Macoun, #284. According to letters at NYS a portion of this collection was sent to BPI in 1945.

Peck's fungus is identical with *Sphaeria rhodospila* Berk.& Curt. It has been termed *Herpotrichia rhodospila* (Berk.& Curt.) Sacc., but does not belong in that genus. Dearness studied Peck's collection and proposed that it was better disposed in *Bertiella*. The genus *Bertiella* (Sacc.) Sacc. & P. Syd. (Syll. Fung. 14: 19, in tab. 1899) is lectotypified by *Bertia macrospora* Sacc. This species has bitunicate asci (Nannfeldt, 1975) and hyaline, fusoid, one to three-septate ascospores (Prep. micr. Ex hb PAD TYPUS, in UPS). Ascomata were described as densely gregarious to confluent, superficial, subrounded, obtusely verruculose. The genus is used to include this North American taxon, which is related to *Teichospora*.

Bertiella rhodospila (Berk. & Curt.) Barr, comb. nov. Figs. 42-44.

Basionym: *Sphaeria rhodospila* Berk. & Curt. Grevillea 4: 141. 1876.

Herpotrichia rhodospila (Berk. & Curt.) Sacc. Syll. Fung. 2: 213. 1883.

Ascomata immersed erumpent, gregarious in and erumpent from blackened crust involving outer layers of wood, pyriform, base somewhat applanate at times, 190-440 μm diam; apex bluntly papillate, orange to red, surface dull black, roughened and irregular; peridium firm, composed of layers of small cells, dark reddish brown externally, reddish to hyaline internally, orange or red toward apex; red pigment leaching out in 3% KOH. Asci bitunicate, basal, clavate, 50-85(-90) × 8-11 μm. Pseudoparaphyses numerous, narrowly cellular. Ascospores hyaline or faintly pigmented in age, 16-25 × 3-5 μm, fusoid, asymmetric, 1-3 septate, slightly constricted at primary submedian septum, cell above enlarged; wall smooth; contents granular; overlapping biseriate in ascus.

In addition to the type specimen of *Melogramma effusum*, other specimens examined include: Curtis, #5026, lign. *Cyrilla*, Society Hill, South Carolina, Oct. 1855 (isotype of *Sphaeria rhodospila*, FH). Fungi of Canada #694, dead wood, Ottawa, 30 April 1897 (NY); DAOM #85515, #85515, #85517, #85519, #105299, #115186, all from Ontario (DAOM). Flora Ludoviciana #1692, old oak stump, St. Martinsville, Louisiana, 8 Jan. 1889, A. B. Langlois (NY). *Populus*, Gill - Elder road, Carp Lake, Emmet Co., Michigan, 11 Sept 1969, Barr #5521 (MASS).

***elliptica*, (*Melanconis*)** Peck, Ann. Rep. New York State Mus. 25: 102. (for 1871) 1873.

Diatrype elliptica (Peck) Peck, Ann. Rep. New York State Mus. 28: 87. (for 1874) 1876.

Pseudovalsa lanciformis (Fr.) Ces. & de Not. var. *elliptica* (Peck) Sacc., Syll. Fung. 2: 135. 1883.

Type specimen (syntype): on branches of *Betula populifolia*, Center, (= Karner) Albany Co., New York, Nov 1871, C. H. Peck; (lectotype): same data but April 1871.

Wehmeyer (1941) did not distinguish a separate variety and regarded Peck's fungus as synonymous with **Pseudovalsa lanciformis** (Fr.) Ces. & de Not.; Barr (1978) concurred with this judgement.

***episphaeria*, (*Dothidea*)** Peck, Ann. Rep. New York State Mus. 30: 64. (for 1876) 1878.

Phyllachora episphaeria (Peck) Sacc., Syll. Fung. 2: 608. 1883.

Type specimen (holotype): on old *Diatrype stigma*, Maryland, Otsego Co., New York, Sept 1876, C. H. Peck.

This is a synonym of **Berlesiella nigerrima** (Blox.) Sacc., according to Barr (in Bigelow & Barr, 1969).

***erineophila*, (*Microsphaera*)** Peck, Bull. Torrey Bot. Club 10: 75. 1883.

Type specimen (holotype): on the erineum of beech leaves, Cobden, Union Co., Illinois, F. S. Earle and A. B. Seymour.

According to Salmon (1900) this is a synonym of *Microsphaera alni* (Wallr.) Salmon; the earlier name is **M. penicillata** (Wallr.: Fr.) Lév. var. **penicillata** (W. B. Cooke, 1952).

***erratica*, (*Cucurbitaria*)** Peck, Bull. Torrey Bot. Club 34: 349. 1907.

Type specimen: on *Aescululs glabra*, Black River, Russia Township, Lorain Co., Ohio, 9 March 1907, C. B. Wilson, #15.

The description gives Oberlin, Ohio, as the locality and F. O. Grover as collector; however, apparently Grover merely communicated the collection made by Wilson to Peck.

Saccardo (Sylloge Fung. 22: 288. 1913) noted that the fungus differed from the other species of *Cucurbitaria* in having pilose perithecia and no paraphyses, and tentatively proposed a new genus *Peckiomyces* to accommodate the species. He did not make a new combination, and in the index to Volume 22, *Peckiomyces* is placed in a typeface denoting a synonym. Welch (1926) also excluded *C. erratica* from *Cucurbitaria*. Both Peck and Welch remarked on the absence of paraphyses. The type specimen, however, shows numerous narrow pseudoparaphyses above the asci and extending into the apical pore. The erumpent, short appendaged ascomata with a broad truncate apex are typical of those found in *Fenestella*.

Fenestella erratica (Peck) Barr, comb. nov. Figs. 33, 34.

Ascomata seated on basal subiculum, erumpent through periderm, forming groups 1-2 mm diam, or elongate rows up to 5-6 × 2 mm, rarely separate, globose or conic, (300-)450-550 μm diam, apex broad, truncate, surface dull black, usually somewhat roughened and irregular with protruding clumps of cells, with numerous short hyphal appendages near apex, 15-100 μm long, ca. 4 μm wide, dark brown, with a few septa, ends bluntly rounded; wall 30-40 μm wide, outer layers of dark brown pseudoparanchyma, 20-25 μm wide, inner layers 10-15 μm wide, light brown to hyaline, slightly compressed cells, often thickened above; basal subiculum of interwoven hyphae, reddish brown. Asci 155-185 × 15.5-20 μm, cylindric, bitunicate, short stipitate, arising from base; pseudoparaphyses numerous, narrow, trabeculate, extending into apical pore region. Ascospores 24-30 × 11-13 μm, yellowish brown becoming dull dark brown, ellipsoid becoming obovoid, usually straight, tapered to rounded or blunt ends, ± symmetric, (5-)7-8(-9) septate, constricted at primary septum, 2-3 longitudinal septa in all cells, often oblique in end cells, wall smooth, uniseriate, often obliquely, in the ascus.

Among the ascomata are numerous pycnidia, 150-200 μm diam, 100-150 μm high, black, collapsing cupulate, bearing a few hyphal appendages; conidia are 2.5-3.5 × 1 μm, hyaline, one-celled, with globule near each end, numerous.

euphorbiae, (Erysiphe) Peck, Bull. Buffalo Soc. Nat. Sci. 1: 70. 1873; Ann. Rep. New York State Mus. 26: 80. (for 1872) 1874.

Microsphaera euphorbiae (Peck) Berk. & Curt., Grevillea 4: 160. 1876.

Type specimen (holotype): on leaves of *Euphorbia hypericifolia*, Greenbush, Rensselaer Co., New York, Oct 1872, C. H. Peck. Peck's notebooks indicate that a portion of this collection was sent to W. R. Gerard Dec 1875.

Salmon (1900) recognized the species as *Microsphaera euphorbiae* (Peck) Berk. & Curt. Braun (1984b) maintains that the species belongs in *Erysiphe* where Peck placed it.

eutypoides, **(*Leptosphaeria*)** Peck, Ann. Rep. New York State Mus. 38: 105. (for 1884) 1885.
Type specimen: on dead stalks of *Chenopodium album*, West Albany, Albany Co., New York, May 1884, C. H. Peck.

Ellis and Everhart (1892) placed Peck's species in synonymy with *Pleospora calvescens* (Fr.) Tul., but Wehmeyer (1961) did not mention *L. eutypoides*. Peck's fungus agrees with *Pleospora calvescens* except that all of the ascospores seen in mounts from the type collection were transversely septate only.

Pleospora calvescens is the type species of *Chaetoplea* (Sacc.) Clements in Clements and Shear (1931). *Leptosphaeria eutypoides* is a synonym of **Chaetoplea calvescens** (Fr.) Sacc. ex Clements in Clements & Shear. Despite the habit of *C. calvescens* in herbaceous stems, the genus is more closely related to *Teichospora* than to *Pleospora* by virtue of the symmetric, ellipsoid-fusoid ascospores in cylindric-clavate asci, and by the *Microdiplodia* anamorph.

exaridum, **(*Lophodermium*)** Cooke & Peck in Cooke, Bull. Buffalo Soc. Nat. Sci. 3: 36. 1875.
Hysterium exaridum Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 63. (for 1875) 1878.
Lophodermina exarida (Cooke & Peck) Tehon, Illinois Biol. Monogr. 13(4): 95. 1935.
Type specimen (isotype): on old leaves of *Kalmia angustifolia*, Sand Lake, Rensselaer Co., New York, June, C. H. Peck. A portion was sent to Cooke 21 Feb 1872 as #212 with the host cited as "*Kalmia angust.*" According to Peck's notebooks a further duplicate was sent to Gerard 17 Feb 1875.

Cooke described *Lophodermium exaridum* Cooke & Peck on leaves of *Magnolia* (which appears to be a mistake), New York (Peck) and gave a very brief description. Peck provided an identical description under the name *Hysterium exaridum* and gave the host as *Kalmia angustifolia.* Saccardo (Syll. Fung. 2: 792. 1883) reported *Lophodermium exaridum* Cooke & Peck, and cited both references. Peck (Bull. New York State Mus. 131: 115. 1908) recorded *Hysterium exaridum* Cooke & Peck, cited both references and indicated Saccardo's treatment as "(*Lophodermium exaridum* Cooke & Peck in Sylloge 2)."

The species is a good *Lophodermium* according to Darker's (1967) key to genera of Hypodermataceae and should be cited as **Lophodermium exaridum** Cooke & Peck in Cooke not as "(Cooke & Peck) Sacc."

exercitalis, **(*Sphaeria*)** (*Caulicolae*) Peck, Ann. Rep. New York State Mus. 30: 66. (for 1876) 1878.
Diaporthe exercitalis (Peck) Sacc., Syll. Fung. 1: 693. 1882.
Type specimen (holotype): on dead stems of herbs, Hunter, Catskill Mountains, Greene Co., New York, June 1876, C. H. Peck.

This is synonymous with **Diaporthe linearis** (Nees) Nits. according to Wehmeyer (1933).

exigua, **(*Sphaeria*)** (*Denudatae*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 30: 65. (for 1876) 1878.
Zignoella exigua (Cooke & Peck) Sacc., Syll. Fung. 2: 215. 1883.
Type specimen (isotype): on decaying wood, Richfield Springs, Otsego Co., New York, July, probably 1872, G. W. Clinton (portion sent to Cooke 23 July 1873 as #316).

The fungus is identical with **Melanopsamma pomiformis** (Pers. ex Fr.) Sacc.

eximia, **(*Sphaeria*)** Peck, Ann. Rep. New York State Mus. 28: 78. Pl. 2, Figs. 14-17. (for 1874) 1876.
Type specimen (holotype): on hare's dung, Kasoag, Oswego Co., New York, July 1874, C. H. Peck (now in two packets at NYS).

Peck (Ann. Rep. 31: 60. 1879) noted that "Owing to the delay in the issue of the 28th Report, the name of this was antedated by *S. amphicornis* Ellis." Both names are synonymous with **Podospora appendiculata** (Auersw.) Niessl according to Mirza and Cain (1969).

extensa, **(*Microsphaera*)** Cooke & Peck, J. Bot. II. 10: 12. 1872; Ann. Rep. New York State Mus. 25: 95. (for 1871) 1873.
Type specimen: on leaves of *Quercus rubra* (*Q. borealis*) Greenbush, Albany Co., New York, Aug 1870, C. H. Peck. Portion consisting of a single leaf sent to Cooke 10 Nov 1871 as #157. Now at (K) along with additional material ex herb. Plowright.

Peck had another collection on *Quercus rubra*, Bethlehem, Albany Co., New York, Oct.

The fungus was recognized as *Microsphaera alni* var. *extensa* (Cooke & Peck) Salmon (1900); the earlier epithet is **Microsphaeria penicillata** (Wallr.: Fr.) Lév. var. **extensa** (Cooke & Peck) W. B. Cooke (1952).

exudans, **(*Valsa*)** Peck, Ann. Rep. New York State Mus. 40: 67. (for 1886) 1887.
Anthostoma ellisii Sacc. var. *exudans* Peck in Sacc., Syll. Fung. 9: 521. 1891; as *Anthostoma microsporum* Karst. var. *exudans* (Peck) Ellis & Everh., N. Amer. Pyrenomyc. p. 582. 1892.

Type specimen (holotype): on bark of *Alnus incana*, Elizabethtown, Essex Co., New York, Sept 1886, C. H. Peck.

Nannfeldt's (1972) lucid study of the species of *Camarops* includes Peck's name and specimen as a synonym of **Camarops microspora** (Karst.) Shear.

farinosa, (*Diaporthe*) (*Chorostate*) Peck, Ann. Rep. New York State Mus. 40: 69, 70. (for 1886) 1887.

Type specimen (holotype): on branches of *Carpinus caroliniana*, Argusville, Schoharie Co., New York, July 1886, C. H. Peck.

In the type description the host is given as *Tilia americana*. Wehmeyer (1941) included Peck's species in the synonymy of **Melanconis chrysostroma** (Fr.) Tul. var. **ellisii** (Rehm) Wehm. and indicated that the host was *Carpinus*, not *Tilia*. Fig. 113.

femoralis, (*Valsa*) Peck, Ann. Rep. New York State Mus. 28: 74, 75. (for 1874) 1876.

Cryptospora femoralis (Peck) Sacc., Syll. Fung. 2: 362. 1882.

Winterella femoralis (Peck) O. Kuntze, Rev. Gen. Pl. 1: 34. 1891.

Ophiovalsa femoralis (Peck) Petrak, Sydowia 19: 273. 1965.

Type specimen (lectotype): on *Alnus*, West Albany, Albany Co., New York, June, C. H. Peck, duplicate sent to M. C. Cooke June 5, 1871 as #34; (syntypes): on *Alnus*, North Greenbush, Rensselaer Co., N. Y., July 1874; on dead branches of basswood, Buffalo, G. W. Clinton.

J. Reid studied the two collections on *Alnus* cited above and annotated them as being *Cryptospora femoralis*. The specimen on basswood he annotated as undescribed. Fig. 114.

fenestrata, (*Patellaria*) Cooke & Peck in Cooke, Bull. Buffalo Soc. Nat. Sci. 3: 26. 1875; Ann. Rep. New York State Mus. 28: 68. (for 1874) 1876.

Blitrydium fenestratum (Cooke & Peck) Sacc., Syll. Fung. 8: 205. 1889.

Triblidium fenestratum (Cooke & Peck) O. Kuntze, Rev. Gen. Pl. 3: 537. 1898.

Type specimen (isolectotype): dead branches of *Populus*, Center (= Karner), Albany Co., New York, Oct-Nov, C. H. Peck; (portion sent to Cooke Mar 5, 1872 as #253; duplicate sent to BPI 1945; portion at CUP-D; duplicate sent to Gerard Feb 17, 1845).

This fungus has an open "apothecium" with the pseudoparaphyses tips darkened and encrusted to form a pseudoepithecium. With the muriform ascospores in bitunicate asci it belongs in *Tryblidaria*. Ellis N.A.F. 993 as *Patellaria fenestrata* and Seaver Ascomycetes & Lower Fungi #30 as *Blitrydium fenestratum* are identical with the type specimen.

Tryblidaria fenestrata (Cooke & Peck) Barr, comb. nov. Figs. 11, 12.

Ascomata superficial, discoid, sessile, black, margined, up to 1-1.5 mm diam, 275-385 μm high, surface smooth or convoluted; wall 20-30 μm wide, of small thick-walled cells arranged in ± vertical rows, with thickened locule base composed of hyaline pseudoparenchyma, 60-100 μm wide. Asci 90-100 × 25-30 μm, bitunicate, oblong clavate, sessile, (2-)4-6(-8) spored; pseudoparaphyses narrow cellular, numerous between asci, above encrusted and blackish-blue pigmented as pseudoepithecium. Ascospores 30-50 × 12-15 μm, hyaline soon brown, obovoid, straight or inequilateral, usually asymmetric, 11-15 septate, constricted at least at primary septum, 1-3 longitudinal septa, contents guttulate, wall smooth, surrounded by gel coat 3 μm wide, overlapping biseriate in the ascus.

fenestrata, (*Pyrenophora*) Peck, Bull. Torrey Bot. Club 11: 28. 1884.

Type specimen (holotype): on herbaceous stalks, Utah, 1881, M. E. Jones (no number).

Wehmeyer (1961) synonymized this species with *Pleospora tragacanthae* Rabenh. According to Barr's study of the type specimen, it is instead **Pleospora comata** Niessl. The ascospores are asymmetrically septate and larger than those of *P. tragacanthae* (27-42 × 13-21 μm). Peck provided ascospore sizes as ".0016-.002 × .0007-.0009 in.," approximately 40-50 × 18-23 μm; Wehmeyer found them to be 38-43 × 14-18 μm; Barr measured them as 40-50 × 20-22 μm.

flexuosa, (*Uncinula*) Peck, Trans. Albany Inst. 7: 215. 1872; Ann. Rep. New York State Mus. 26: 80. (for 1872) 1874.

Type specimen (holotype): on leaves of *Aesculus hippocastanum*, Buffalo, Erie Co., New York, G. W. Clinton.

Salmon (1900) recognized *Uncinula flexuosa* as a separate species. It is now termed **Uncinuliella flexuosa** (Peck) U. Braun, Nova Hedwigia 34: 712. 1981.

fraxinea (*Sphaerella*) Peck, Ann. Rep. New York State Mus. 35: 145. (for 1881) 1884.

Type specimen (holotype): on fallen leaves of *Fraxinus*, Helderberg Mts., New York, May 1881, C. H. Peck.

Although neither Homer House, Roy Cain or M. E. Barr could find mature spores in the type, Peck illustrated spores in a small pencil drawing which was included in the type packet. House included Peck's species in the synonymy of **Mycosphaerella effigurata** (Schw.) House, Bull. New York State Mus. 233-234: 27. 1921.

***fraxinicola*, (*Valsa*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 59. (for 1875) 1878.

Eutypella fraxinicola (Cooke & Peck) Sacc., Syll. Fung. 1: 154. 1882.

Engizostoma fraxinicola (Cooke & Peck) O. Kuntze, Rev. Gen. Pl. 3: 474. 1898.

Type specimen (isotype): on branches of *Fraxinus*, Tyre, Seneca Co., New York, Sept 1871, C. H. Peck (portion sent to Cooke Feb 14, 1872 as #232).

This is identical with **Eutypella ludibunda** Sacc.

***fraxinina*, (*Valsa*)** Peck, Bull. Torrey Bot. Club 11: 28. 1884.

Engizostoma fraxininum (Peck) O. Kuntze, Rev. Gen. Pl. 3: 474. 1898.

Type specimen (holotype): on branches of *Fraxinus americana*, Canada, no specific locality, 1882, J. Macoun, #46.

Barr cannot see any reason to separate this from **Valsa grisea** Peck, which was described in the same publication.

***friesii* var. *castaneae*, (*Microsphaera*)** Cooke & Peck, J. Bot. II. 10: 13. 1872.

Type specimen (isotype): on leaves of *Castanea vesca* (*C. dentata*), Sand Lake, Rensselaer Co., New York, 1870, C. H. Peck (portion sent to Cooke Nov 10, 1871 as #156).

Salmon (1900) placed the variety in synonymy with *M. alni* (Wallr.) Salmon; the earlier epithet is **M. penicillata** (Wallr.: Fr.) Lév. var. **penicillata** (W. B. Cooke, 1952).

***friesii* var. *syringae*, (*Microsphaera*)** (Schw.) Cooke & Peck, J. Bot. II. 10: 12. 1872.

Erysiphe syringae Schw., Trans. Amer. Philos. Soc. II. 4: 270. 1882.

Peck had specimens on *Syringa vulgaris* from Albany, Albany Co., and from Greenbush, Rensselaer Co., New York (portion of the Greenbush collection sent to Cooke Nov 10, 1871 as #151). This is also a synonym of **Microsphaeria penicillata** var. **penicillata**.

***friesii* var. *vaccinii*, (*Microsphaera*)** (Schw.) Cooke & Peck, J. Bot. II. 10: 12. 1872.

Erysiphe vaccinii Schw., Trans. Amer. Philos. Soc. II. 4: 270. 1882. (in part)

Peck had collections on *Vaccinium*, North Elba, Essex Co., New York, and on *Vaccinium corymbosum*, North Greenbush, Rensselaer Co., New York (portion of N. Greenbush collection sent to Cooke 10 Nov 1871 as # 153 but not 153a).

This is *Microsphaera penicillata* var. *vaccinii* (Schw.) W. B. Cooke (1952), or recognized as a separate species, **M. vaccinii** (Schw.) Cooke & Peck, J. Bot. II. 10: 13. 1872.

frostii, (Diatrypella) Peck, Bot. Gaz. 3:35. 1878.

Type specimen (holotype): on branches of *Acer*, Brattleboro, Windham Co., Vermont, C. C. Frost #65.

The fungus is a clearly defined species recognizable by the greenish interior of stromata, and is common on branches of sugar maple.

***fulgida*, (*Sphaeria*) (*Caulicolae*)** Cooke & Peck in Cooke & Ellis, Grevillea 6: 15. 1877; as Clinton & Peck in Peck, Ann. Rep. New York State Mus. 29: 62. (for 1875) 1878.

Ophiobolus fulgidus (Cooke & Peck) Sacc., Syll. Fung. 2: 346. 1883.

Rhaphidospora fulgida (Cooke & Peck) Cooke, Grevillea 18: 16. 1889.

Type specimen (isotype): on stalks of *Ambrosia trifida*, Albany, Albany Co., New York, June, C. H. Peck (portion sent to Cooke 28 March 1872 as #271).

Two species are present on the isotype material of *Sphaeria fulgida*, as Drechsler (1934) observed. He described and illustrated both species. Shoemaker (1976) treated both in *Ophiobolus*. Both species seem better arranged in *Leptosphaeria* according to Holm's (1957) interpretation. The combination **Leptosphaeria fulgida** (Cooke & Peck in Cooke & Ellis) Barr, comb. nov. designates the species with 7-septate ascospores, 55-95 × 3-3.5 μm. For that with (10-) 15-(18-)septate ascospores, 85-125 × 4-4.5 μm, Barr proposes **Leptosphaeria drechsleri** (Shoemaker) Barr, comb. nov. Basionym: *Ophiobolus drechsleri* Shoemaker, Canad. J. Bot. 54: 2376. 1976.

***fusispora*, (*Patellaria*)** Cooke & Peck in Cooke, Bull. Buffalo Soc. Nat. Sci. 3: 26. 1875; Ann. Rep. New York State Mus. 28: 67, 68. (1874) 1876.

Karschia fusispora (Cooke & Peck) Sacc., Syll.Fung.8:781. 1889.

Type specimen (isotype): on decaying wood of black ash (*Fraxinus*), Portville, Cattaraugus Co., New York, Sept 1871, C. H. Peck (Portion sent to Cooke 1 Nov 1871 as #133; small duplicate in CUP-D; duplicate sent to Gerard 17 Feb 1875).

The species has apothecia, unitunicate asci, paraphyses which form a pseudoepithecium, and narrowly elliptic, reddish brown, one-septate, finely longitudinally striate ascospores. It is a synonym of **Dactylospora stygia** (Berk. & Curt.) Hafellner var. **stygia**, Nova Hedwigia Beih. 62: 137. 1979.

***gaultheriae*, (*Sphaerella*)** Cooke & Peck, Grevillea 7: 42. Dec. 1878, (this was an error for Cooke & Ellis (as "C. & P.") in the original publication).

***gerardii*, (*Hysterium*)** Cooke & Peck in Cooke, Bull. Buffalo Soc. Nat. Sci. 3: 33. 1875.

Hysterographium gerardii (Cooke & Peck) Sacc., Syll. Fung. 2:783. 1883.

Type specimen (isotype): on decorticated trunk of *Castanea*, Poughkeepsie, Dutchess Co., New York, Aug 1871, W. R. Gerard (NYS); herb. Cooke as #123, sent 24 Oct 1871, includes drawing of spores and asci (K).

This is a form of **Hysterographium mori** (Schw.) Rehm, according to Zogg (1943, 1962).

***grandis*, (*Xylaria*)** Peck, Ann. Rep. New York State Mus. 26: 85. (for 1872) 1874.

Type specimen (holotype): on the ground, Portage, Livingston Co., New York, 1872, G. W. Clinton.

The fungus is scarcely separable from **Xylaria polymorpha** (Pers.: Fr.) Grev. The distinguishing character was cited as the short sterile apices of stromata, which are fertile to the tip in *X. polymorpha*. Martin (1970) in a revision of the genus did not consider this character to be of specific value. Fig. 115.

***grisea*, (*Valsa*)** Peck, Bull. Torrey Bot. Club 11: 28. 1884.

Engizostoma griseum (Peck) O. Kuntze, Rev. Gen. Pl. 3: 474. 1898.

Type specimen (syntypes): on branches of *Acer rubrum*, Canada, 1882, J. Macoun, #47; on *Fraxinus*, 1882, J. Macoun, #22. A third collection on *Quercus*, Canada, 1882, J. Macoun, #49 is also at NYS.

The species is a member of the *Circinatae* group of *Valsa*. Pending detailed revisionary studies, it is accepted as **Valsa grisea** Peck.

***hamamelidis*, (*Patellaria*)** Peck, Ann. Rep. New York State Mus. 33: 32. Pl. 2, Figs. 7-10. (for 1879) 1883.

Lecanidion hamamelidis (Peck) Sacc., Syll. Fung. 8: 800. 1889.

Dermatella hamamelidis (Peck) Durand, Bull. Torrey Bot. Club 29: 464. 1902.

Dermea hamamelidis (Peck) Groves, Mycologia 32: 743. 1940.

Type specimen (holotype): on branches of *Hamamelis virginiana*, North Greenbush, Rensselaer Co., New York, May, C. H. Peck (duplicate in CUP-D).

***hirtissima*, (*Sphaeria*)** Peck, Ann. Rep. New York State Mus. 28: 78. (for 1874) 1876.

Rosellinia hirtissima (Peck) Sacc., Syll. Fung. 1: 271. 1882.

Type specimen (holotype): on decaying pine wood, Center (= Karner), Albany Co., New York, Nov 1874, C. H. Peck.

Ellis and Everhart (1892) considered this to be a synonym of *Rosellinia trichota* (Cooke & Ellis) Ellis & Everh. Because *R. hirtissima* was described as a species and *trichota* as a variety, Peck's epithet would be the valid name of the two. However, in Barr's opinion the fungus is a species of *Coniochaeta*, **Coniochaeta malacotricha** (Niessl) Trav.

howeianum, (Hypoxylon) Peck, Ann. Rep. New York State Mus. 24: 98. (for 1870) 1872.

Type specimen (holotype): on fallen branches of deciduous tree, Center (= Karner), Albany Co., New York, Nov, C. H. Peck (duplicate sent to BPI in 1945).

Miller (1961) recognized this as a distinct species. Fig. 116.

***humulina*, (*Sphaeria*)** (*Caulicolae*) Peck, Ann. Rep. New York State Mus. 32: 52. (for 1878) 1880.

Zignoella humulina (Peck) Peck, Bull. New York State Mus. 1(2): 24. 1887.

Metasphaeria humulina (Peck) Sacc., Syll. Fung. 9: 828. 1891.

Type specimen (holotype): on old hop vines (*Humulus lupulus*), Carlisle, Schoharie Co., New York, June 1878, C. H. Peck.

The fungus is another of the forms of **Discostroma corticola** (Fuckel) Brockmann, Sydowia 28: 313. 1976.

hyalinum, (Hysterium) Cooke & Peck in Cooke, Bull. Buffalo Soc. Nat. Sci. 3: 33. 1875.

Gloniella hyalina (Cooke & Peck) Sacc., Syll. Fung. 2: 766. 1883. Type specimen: on decorticated wood of deciduous tree, Cold Spring, New York, June 1871, C. H. Peck. The type was sent to Cooke, 27 June 1871, as "#47 *Hysterium rousselii*." Apparently no duplicate was retained by Peck.

Lohman (1934) studied, illustrated and redescribed the type specimen (from Kew) and concluded that it was a valid species of *Hysterium*, whose ascospores become pale brown at maturity. From cultures of a specimen which he collected in Massachusetts, Lohman obtained *Sporidesmium* conidia.

***hymenii*, (*Peckiella*)** Peck, Bull. New York State Mus. 116: 28, 29. 1907.

Type specimen (holotype): on the hymenium of *Lactarius vellereus*, Wading River, Suffolk Co., New York, Aug 1905, C. H. Peck.

As indicated under **Hypomyces banningiae** Peck, *Peckiella hymenii* is considered to be a synonym of that species.

***hymenioides*, (*Peckiella*)** Peck, Bull. Torrey Bot. Club 34: 102. 1907.

Type specimen (holotype): on the hymenium of *Lactarius uvidus*, Newfane, Windham Co., Vermont, Aug 1907, G. S. Burlingham. Burlingham's portion of the collection (isotype) is at NY.

This is a synonym of **Hypomyces lateritius** (Fries) Tulasne, Ann. Sci. Nat. Bot. IV. 13: 11. 1860.

***hypoxylon*, (*Epichloe*)** Peck, Ann. Rep. New York State Mus. 27: 108. (for 1873) 1875.
Hypocrella hypoxylon (Peck) Sacc., Syll. Fung. 2: 581. 1883.
Hypocrea hypoxylon (Peck) Ellis & Everh., J. Mycol. 2: 67. 1886.
Dothichloe hypoxylon (Peck) Atkinson, Bull. Torrey Bot. Club 21: 223. 1894.
Balansia hypoxylon (Peck) Atkinson, J. Mycol. 11: 254, 255.
1905.
Atkinsonella hypoxylon (Peck) Diehl, Agric. Monogr. U.S.D.A. 4: 49. 1950.
Type specimen (holotype): on living stems of grass, Sand Lake, Rensselaer Co., New York, July 1872, C. H. Peck.

Diehl (1950) described the genus *Atkinsonella* for this species.

***impatientis*, (*Sphaerella*)** Peck & Clinton in Peck, Ann. Rep. New York State Mus. 30: 67. (for 1876) 1878.
Mycosphaerella impatientis (Peck & Clinton) House, Bull. New York State Mus. 233-234: 28. 1921.
Type specimen (lectotype): on spotted leaves of *Impatiens fulva*, Buffalo, Erie Co., New York, June 1876, G. W. Clinton; (syntype): on *Impatiens fulva*, Adirondack Mountains, New York, Aug 1876, C. H. Peck (this collection was distributed as de Thümen, Mycotheca Universalis #963).

***impulsa*, (*Valsa*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 27: 109. (for 1873) 1875.
Diaporthe impulsa (Cooke & Peck) Sacc., Syll. Fung. 1: 618. 1882.
Type specimen (lectotype): on branches of *Sorbus americana*, Upper Ausable and Edmund's Pond, Adirondack Mountains, Essex Co., New York, July 1871, C. H. Peck (K) (this was probably the collection sent to Cooke 10 April 1872 as #273. It could not be located at NYS); (syntypes): same host, Adirondack Mountains, New York, C. H. Peck; North Elba, Sept, Essex Co., New York, C. H. Peck.

The description merely cited "Adirondack Mountains, August." Three packets are known from different localities in the Adirondack Mountains. Wehmeyer (1933) designated the Upper Ausable and Edmund's Pond specimen as type and recognized **Diaporthe impulsa** as a valid species. Some duplicate material was sent to Ellis 1 Nov 1876 labelled as from Adirondack Mts. on *Pyrus americana* and is at NY. Fig. 117.

***inaequalis*, (*Hypomyces*)** Peck, Bull. Torrey Bot. Club 25: 328. 1898.
Type specimen (holotype): parasitic on some stout, thick-stemmed agaric, North Bridgton, Maine, Sept 1897, C. L. Fox.

This is a synonym of **Hypomyces hyalinus** (Schweinitz: Fries) Tulasne, Ann. Sci. Nat. Bot. IV. 13: 11, 12. 1860.

***indigotica*, (*Patellaria*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 25: 98. (for 1871) 1873.
Lecanidion indigotica (Cooke & Peck) Sacc., Syll. Fung. 8: 797. 1889.
Type specimen (isotype): on decaying wood, Savannah, Wayne Co., New York, Oct 1871, C. H. Peck (portion sent to Cooke 21 Oct 1871 as #117).

This is synonymous with **Lecanidion atratum** (Hedw.: Fr.) Endl.

***indistincta*, (*Sphaerella*)** Peck, Ann. Rep. New York State Mus. 28: 81. (for 1874) 1876.
Mycosphaerella indistincta (Peck) Lindau in Engler & Prantl, Nat. Pflanzenfam. 1*: 426. 1897.
Type specimen (holotype): on leaflets of *Pteridium aquilinum*. Center (= Karner), Albany Co., New York, June 1874, C. H. Peck (duplicate sent to NY in 1935 and is at NY).

The species has narrow fusoid ascospores, 20.5-23.5 × 3-3.5 μm and is **Mycosphaerella pteridis** (Desm.) Schroet. in Cohn, Kryptogamenfl. Schlesiens 3(2): 341. 1894.

***innumerabilis*, (*Valsa*)** (*Obvallatae*) Peck, Ann. Rep. New York State Mus. 30: 65. (for 1876) 1878.
Eutypella innumerabilis (Peck) Sacc., Syll. Fung. 1: 156. 1882.
Engizostoma innumerabile (Peck) O. Kuntze, Rev. Gen. Pl. 3: 474. 1898.
Type specimen (holotype): (2 packets) on branches of *Ulmus americana*, Greenbush, Rensselaer Co., New York, May 1876, C. H. Peck.

Ellis and Everhart (1892) reduced Peck's species to synonymy with *E. stellulata* (Fr.) Sacc. Tiffany and Gilman (1965) stated that Ellis and Everhart's concept of *E. stellulata* differed from the original and that the Ellis and Everhart specimens were referrable to *Eutypa ludibunda* Sacc. *Valsa innumerabilis* is a species of *Eutypella* with small asci (25-30 μm long) and medium-sized ascospores 7.5-10 × 1.5-2 μm related to *E. cerviculata* (Fr.) Sacc.

***inornata*, (*Diaporthe*)** Peck, Bull. New York State Mus. 157: 109 (reprint p. 47). 1912.
Chorostate inornata (Peck) Sacc., Syll. Fung. 24: 748. 1928.

Type specimen (holotype): on branches of *Rhus typhina*, Cabin John Bridge, Montgomery Co., Maryland, 15 June 1910, E. Bartholomew, #4326.

This is synonymous with *Cryptodiaporthe aculeans* (Schw.) Wehm. (1933) and was transferred to **Amphiporthe aculeans** (Schw.) Barr (1978).

***inquinans*, (*Leptosphaeria*)** Peck, Bull. New York State Mus. 131: 22, 23. 1909.

Type specimen (holotype): on bark of *Acer saccharum*, Vaughns, Washington Co., New York, 7 April 1907, S. H. Burnham.

This fungus does not appear to be separable from **Cryptosphaeria eunomioides** (Otth) v. Höhnel.

***interstitialis*, (*Sphaeria*)** (*Denudatae*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 61. (for 1875) 1878.

Teichospora interstitialis (Cooke & Peck) Sacc., Syll. Fung. 2: 293. 1883.

Strickera interstitialis (Cooke & Peck) O. Kuntze, Rev. Gen. Pl. 3: 534. 1898.

Type specimen (isotype): (2 packets) on decorticated cherry wood (*Prunus*), Greenbush, Rensselaer Co., New York, Nov, C. H. Peck (portion sent to Cooke 5 March 1872 as #251).

This fungus has depressed ascomata with rounded apices, a much thickened wall, sclerotial internally, and is a species of *Cucurbitaria*. The isotype has ascospores considerably smaller than the sizes provided in the original description (30-35 × 12-16 μm).

Cucurbitaria interstitialis (Cooke & Peck) Barr, comb. nov. Figs. 16-18.

Ascomata grouped with bases immersed in wood, dull black, globose depressed, 330-440 μm diam, 300-385 μm high, apex rounded, very short papillate; wall thick, 52-65 μm wide, of large sclerotial cells. Asci 120-150 × 14-16 μm bitunicate, broadly cylindric, base footshaped, (4-)8-spored; pseudoparaphyses numerous. Ascospores 15-22 × 6-8 μm yellow brown to dark brown, ellipsoid, at times asymmetric and obovoid, (2-)3(-4)-septate, constricted at primary septum, vertical septum through mid cells, large globule in each cell, wall finely roughened in some, remnants of gel coat present in some, uniseriate in the ascus.

***kalmiae*, (*Dothidea*)** Peck, Ann. Rep. New York State Mus. 25: 102. (for 1871) 1873.

Dothidella kalmiae (Peck) Sacc., Syll. Fung. 2: 631. 1883.

Phyllachora kalmiae (Peck) Petrak, Ann. Mycol. 39: 283. 1941.

Type specimen (holotype): on branches of *Kalmia angustifolia*. Sand Lake, Rensselaer Co., New York, Sept, C. H. Peck.

The type specimen consists of blackened stromatic tissue but does not contain asci or ascospores. However, other collections in NYS and elsewhere do bear fertile perithecia and are referrable to *Phyllachora*. Because of the distinctive aspect of the stromata on the host plant, there is no doubt that Peck's specimen is **Phyllachora kalmiae**. Petrak (1941) provided a detailed description of the fungus, based on a collection from Ontario (TRTC 9116).

***kalmiae*, (*Leptosphaeria*)** Peck, Ann. Rep. New York State Mus. 39: 53. (for 1885) 1887.

Gibberidea kalmiae (Peck) Barr, Canad. J. Botany 39: 311. 1961.

Type specimen (holotype): on branches of *Kalmia angustifolia*, Grassy Pond, Adirondack Mts., New York, June 1884, C. H. Peck (a note on the original packet states "send to Sacc." [ardo]).

Holm (1968) critically assessed the genus *Gibberidea* and excluded many disparate elements. He included Peck's fungus in the synonymy of **Melanomma rhododendri** Rehm. (Fig. 19). *Leptosphaeria myricae* Dearness & House, (apparently unpublished?) described from dead branches of *Myrica carolinensis* (?), (or *Myrica gale*), Grassy Pond, Adirondack Mts., New York, C. H. Peck (NYS) does not differ from *M. rhododendri* and is here considered to be another synonym of that species.

***kalmiae*, (*Venturia*)** Peck, Ann. Rep. New York State Mus. 28: 82. Pl. 2, Figs. 6-9. (1874) 1876.

Coleroa kalmiae (Peck) Rehm, Ann. Mycol. 9: 288. 1911.

Gibbera kalmiae (Peck) Barr, Canad. J. Botany 39: 315. 1961.

Type specimen (holotype): on leaves of *Kalmia glauca*, Kasoag, Oswego Co., New York, July 1874, C. H. Peck.

***lanosum*, (*Chaetomium*)** Peck, Ann. Rep. New York State Mus. 28:64. (for 1874) 1876.

Type specimen (holotype): on herbarium specimens of grasses, Albany, Albany Co., New York, 19 May 1874, C. H. Peck.

Ames (1963) considered Peck's species to be a synonym of **Chaetomium globosum** Kunze: Fries.

laschii var. ***acerina*, (*Valsella*)** Peck, Rep. New York State Mus. 40: 68. (for 1886) 1887.

Type specimen (holotype): on branches of *Acer spicatum*, Port Henry, Essex Co., New York, June 1886, C. H. Peck.

In the polysporous genus *Valsella* host specificity is a diagnostic character, and two series of aseospores sizes occur: (3-)5-8 × 1-1.5-2.5 μm and 8-14 × 2.5-3 μm. *Valsella laschii* (Nits.) Sacc. was described from *Cornus*, with ascospores 10 × 3 μm in the larger size range. Peck's var.

acerina has ascospores 7-8 × 1-2 μm in the smaller size range. Host differences as well as ascospore sizes dictate raising the variety to specific rank.

Valsella acerina (Peck) Barr, stat. nov.

Stromata immersed, small, 495-660 μm diam, 275-330 μm high, conceptacle blackened externally, 40-65 μm wide at base and sides, narrowed to 26 μm wide near small white erumpent disc; perithecia 2-4 in a stroma, 130-180 μm diam; wall of perithecia narrow, pallid, conceptacle of brown pseudoparenchyma; disc formed by pallid perithecial ostioles. Asci 35-40 × 8-10 μm unitunicate, oblong, floating free in centrum, apical annulus refractive in water, chitinoid, nonamyloid, polysporous (12 ±) aparaphysate. Ascospores 7-8 × 1-2 μm hyaline, allantoid or scarcely curved, one-celled, contents homogeneous, wall smooth, crowded in the ascus.

Conidial stromata similar in appearance to perithecial, with larger and more erumpent white disc; labyrinthiform chambers lined by short conidiophores; conidia 4-6.5 × 1 μm hyaline, allantoid, one-celled.

latizonata, **(*Hypocrea*)** Peck ex Ellis & Everh., J. Mycol. 2: 63. 1886.

Type specimen: on *Cyathus striatus*, Ohio, 1886, A. P. Morgan, #211.

Hypocrea latizonata is a distinct species. Other specimens at NYS collected and identified by Peck are from Sand Lake and Greenbush, Rensselaer Co.

ledi, **(*Aulographum*)** Peck, Bull. New York State Mus. 150: 23, 24. 1911.

Elsinoe ledi (Peck) Zeller in Zeller & Deremiah, Phytopathology 21: 970. 1931.

Type specimen (holotype): on living leaves of *Ledum groenlandicum*, Fine, St. Lawrence Co., New York, 6 Aug 1910, C. H. Peck.

leonina, **(*Sphaeria*)** (*Villosae*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 60. (for 1875) 1878.

Chaetosphaeria leonina (Cooke & Peck) Sacc., Syll. Fung. 2: 94. 1883.

This collection could not be located in NYS. It is possible that the entire collection was sent to Cooke. From the description of tawny-orange tomentum, the fungus could be a species of *Byssosphaeria*.

"Perithecia subconfluent or rarely scattered, dark-brown, oval, covered with a short thick tawny-orange tomentum, the papillate apex naked; asci clavate or cylindrical; spores biseriate, lanceolate, uniseptate, constricted, at length triseptate, brown, .0014'-.0015' long; paraphyses slender, filiform."

"Cut surface of wood. Portville, September." [Cattaraugus Co., New York, 1871] (sent to Cooke 1 Nov 1871 as #138).

leptasca, **(*Valsa*)** Peck & Clinton in Peck, Ann. Rep. New York State Mus. 29: 59. (for 1875) 1878.

Cryptosporella (*Flageoletia*) *leptasca* (Peck & Clinton) Sacc., Syll. Fung. 1: 469. 1882; Syll. Fung. 14: 525. 1899.

Cryptospora (*Cryptosporella*) *leptasca* (Peck & Clinton) Ellis & Everh., North Amer. Pyreno. p. 532. 1892 (as "C. & P.").

Flageoletia leptasca (Peck & Clinton) v. Hohnel, Ann. Mycol. 16: 126. 1918 (as "C. & P.").

Phomatospora leptasca (Peck & Clinton) Reid & Booth, Canad. J. Bot. 44: 448. 1966.

Type specimen (holotype): on branches of *Rhus typhina*, Buffalo, New York, July-August, G. W. Clinton.

leptosperma, **(*Patellaria*)** Peck, Ann. Rep. New York State Mus. 30: 62. (for 1876) 1878; 31: 59. (for 1877) 1879.

Lecanidion leptospermum (Peck) Sacc., Syll. Fung. 8: 800. 1889.

Holwaya leptosperma (Peck) Durand, Bull. Torrey Bot. Club 28: 353. 1901.

Type specimen (lectotype): on *Acer saccharinum*, (now *A. saccharum*), Oneida, Madison Co., New York, 1875, H. A. Warne; (syntype): Buffalo, Erie Co., N. Y., 1876, G. W. Clinton. (CUP-D has a duplicate of one of these two specimens).

This is a synonym of **Holwaya mucida** (Schulzer) Korf & Abawi subsp. **mucida**, Canad. J. Bot. 49: 1980. 1971, in the Helotiales.

leucostoma, **(*Herpotrichia*)** Peck, Bull. New York State Mus. 1(2): 23, 24. 1887.

This epithet was proposed to replace *H. albidostoma*; for discussion see that species.

leucostomoides, (Valsa) Peck, Ann. Rep. New York State Mus. 38: 103. (for 1884) 1885.

Type specimen (holotype): on branches of *Acer saccharum*, Helderberg Mts., New York, May 1884, C. H. Peck.

This appears to be a distinct species of *Valsa*, related to *V. ambiens* (Pers.: Fr.) Pers., but with white or grayish rather than dark disc.

lichenalis, **(*Sphaeria*)** Peck, Bot. Gaz. 5: 36. 1880.

Pleospora lichenalis (Peck) Sacc., Syll. Fung. 2: 258. 1883.

Type specimen (holotype): on birch bark, Vermont, 1879, C. J. Pringle, #381.

Wehmeyer (1961) excluded the species from *Pleospora* and suggested that it belonged in the Myriangiales. Peck's fungus fits well in *Arthothelium*.

Arthothelium lichenalis (Peck) Barr, comb. nov. Figs. 2-4.

Ascomata pulvinate, rounded, 200 μm diam, 150 high, or irregular with several connected, superficial with bases in periderm, surface black, roughened with scattered brown hyphae; in section pseudoparenchymatous, outer 2-5 layers brown, interior hyaline to yellowish. Asci scattered at various heights, separated by inner pseudoparenchymatous tissues, 60-65 × 24-34 μm oblong or ovate, sessile, wall thick, bitunicate. Ascospores 29.5-33 × 10-12 μm hyaline becoming dull brown, oblong or ± obovoid, ends rounded, 7-8-septate, one or two longitudinal septa in all cells, slightly constricted at primary septum, contents homogeneous, wall smooth, narrow gel coat at times visible, crowded in the ascus.

***linderae*, (*Rosellinia*)** Peck, Ann. Rep. New York State Mus. 49: 24. (for 1895) 1897.

Type specimen (holotype): on branches of *Lindera benzoin*, Catskill Mts., New York, July 1895, C. H. Peck (in two packets) (duplicate sent to BPI 1945).

According to Miller (1961) this is a synonym of **Hypoxylon sassafras** (Schw.:Fr.) Curtis.

***linderae*, (*Valsa*)** Peck, Ann. Rep. New York State Mus. 29: 59. (for 1875) 1878.

Eutypella linderae (Peck) Berlese, Icones Fung. 1: 120. 1894.

Engizostoma linderae (Peck) O. Kuntze, Rev. Gen. Pl. 3:474. 1898.

Type specimen (holotype): on branches of *Lindera benzoin*, Albany, Albany Co., New York, July 1875, C. H. Peck.

***longipila*, (*Chaetosphaeria*)** Peck, Ann. Rep. New York State Mus. 42: 131. (reprint p. 35) (for 1888) 1889.

Type specimen (holotype): on old barrel in a cellar, Flatbush, Long Island, Kings Co., New York, March 1888, J. L. Zabriskie, #508.

The peculiar fungus has long appendages on the perithecia, unitunicate asci, and ascospores with hyaline ends and brown mid portion. These ascospores are small, 10-13.5 × 4.5-5.5 μm one-septate with a broad brown band of pigmentation and appear three-septate. The wall is finely longitudinally striate. At this time it appears best placed in **Litschaueria** as **L. longipila** (Peck) Barr, comb. nov. Figs. 70, 71.

***longirostris*, (*Eutypella*)** Peck, Ann. Rep. New York State Mus. 43: 80 (reprint p. 34), Pl. 4, Figs. 8-12. (for 1889) 1890.

Engizostoma longirostre (Peck) O. Kuntze, Rev. Gen. Pl. 3: 474. 1898.

Type specimen (lectotype): on bark of *Ulmus americana*, Sand Lake, Rensselaer Co., New York, 1889, C. H. Peck; (syntype): Syracuse, Onondaga Co., New York, L. M. Underwood.

Ellis and Everhart (1892) placed this as a synonym of **Eutypella scoparia** (Schw.) Ellis & Everh.

***longitudinalis*, (*Cucurbitaria*)** Peck, Ann. Rep. New York State Mus. 33: 34. Pl. 2, Figs. 23-26. (for 1879) 1883.

Gibberidea longitudinalis (Peck) O. Kuntze, Rev. Gen. Pl. 3: 481. 1898.

Type specimen (holotype): on branches of *Lyonia ligustrina* (*Andromeda ligustrina*) Center (=Karner), Albany Co., New York, May 1879, C. H. Peck.

Welch (1926) excluded the species from *Cucurbitaria* because of absence of stroma or subiculum, and the structure of ascoma wall. **Cucurbitaria longitudinalis** does belong in a broader concept of the genus, in Barr's concept of *Cucurbitaria* sect. *Crotonocarpia*, as does *C. interstitialis* (p. 85). Figs. 20-22.

Ascomata erumpent in long rows, globose, 400-800 μm diam, apex rounded, very short papillate; wall 40-100 μm wide, of pseudoparenchymatic cells, blackened externally, yellowish toward locule, surface dull, roughened and irregular, rimose at times. Asci 100-155 × 13-22 μm bitunicate, cylindric clavate, short stipitate; pseudoparaphyses narrow cellular. Ascospores 24-33 × 9-12 μm yellow brown to dark brown, ellipsoid oblong, ends rounded, 3-5(-7)-septate, longitudinal septum through mid cells, at times oblique in end cells, constricted at primary and secondary septa, with globule in each cell, wall smooth, remnants of gel coat visible in some, uniseriate or partially biseriate in upper part of ascus.

***lycopodii*, (*Sphaerella*)** Peck, Ann. Rep. New York State Mus. 39: 51. (for 1885) 1887.

Mycosphaerella lycopodii (Peck) House, Bull. New York State Mus. 233-234: 28. 1921.

Type specimen (holotype): on scales of dead spikes of *Lycopodium clavatum*, Aiden Lair, Adirondack Mts., Essex Co., New York, June 1884, C. H. Peck.

***lycopodiicola*, (*Leptosphaeria*)** Peck, Ann. Rep. New York State Mus. 38: 105. Pl. 2, Figs. 16-19. (for 1884) 1885.

Type specimen (holotype): on dead peduncles of *Lycopodium clavatum*, Aiden Lair, Essex Co., Adirondack Mts., New York, June 1884, C. H. Peck.

The name is a synonym of **Phaeosphaeria fuckelii** (Niessl) Holm, according to Holm (1957).

***lythri*, (*Leptosphaeria*)** Peck, Bull. Torrey Bot. Club 33:220-221. 1906.

Type specimen (holotype): stalks of *Lythrum alatum*, Stockton, Rooks Co., Kansas, 2 Oct 1905, E. Bartholomew (in two packets).

The fungus has muriform ascospores and is not a species of *Leptosphaeria*. It agrees in all respects with Wehmeyer's (1961) description and illustration of *Pleospora rubicunda* Niessl var. *americana* Wehm. This taxon has recently been placed as a synonym of **Massariosphaeria rubelloides** (Plowright ex Cooke) Crivelli, Diss. ETH Nr. 7318: 146. 1983. *Leptosphaeria lythri* fits well in the species and is also relegated to synonymy of *M. rubelloides*.

***macrospora*, (*Poronia*)** Peck, Bull. Torrey Bot. Club 33: 220. 1906.

Type specimen (holotype): Rich sandy ground in a garden. New Haven, Connecticut, 23 Dec 1905, P. W. Graf.

The stroma shape, long tapered rooting stipe, and the large ascospores are suggestive of **Podosordaria pedunculata** (Dicks. ex S. F. Gray) Dennis (Kew Bull. 12: 306. 1957).

macrospora, (Uncinula) Peck, Trans. Albany Inst. 7: 215. 1872; Ann. Rep. New York State Mus. 25: 96. (for 1871) 1873.

Type specimen (holotype): on leaves of *Ulmus*, Buffalo, Erie Co., New York, 27 Oct 1871, G. W. Clinton. The original packet sent to Peck from Clinton is annotated "Uncinulae Bovinae, Lev., 384. Oct. 27, 1871."

Salmon (1900) recognized this as a valid species of *Uncinula*.

***macrosporium*, (*Hysterium*)** Gerard in Peck, Ann. Rep. New York State Mus. 26: 83. (for 1872) 1874.

Type specimen (holotype): on wood of *Pinus*, North Greenbush, Rensselaer Co., New York, Nov, C. H. Peck (in two packets). Duplicate sent to Gerard 17 Feb 1875.

Bisby (1932) and Zogg (1962) considered this a valid species of *Hysterium*. **Hysterium macrosporium** is similar to *H. pulicare* Pers.: Fries except for larger ascospores in which the end cells are pigmented as in the two mid cells. Fig. 118.

***maculans*, (*Venturia*)** Peck, Ann. Rep. New York State Mus. 28: 81, 82. (for 1874) 1876.

Type specimen (holotype): on leaves of *Betula populifolia*, Center (= Karner), Albany Co., New York, May 1874, C. H. Peck; also distributed as Ellis, North American Fungi #900 *Venturia ditricha* (Fr.) Auersw.

This is a form of **Venturia ditricha** (Fr.) Karst., as Peck recognized in Ann. Rep. 30: 77. 1878.

magnatum (Lophiostoma) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 26: 86. (for 1872) 1874 (nomen nudum): 29: 64. (for 1875) 1878.

Navicella magnata (Cooke & Peck) O. Kuntze, Rev. Gen. Pl. 3: 500. 1898.

Type specimen (isotype): on decaying wood, Tyre, Seneca Co., New York, Sept 1871, C. H. Peck (portions sent to Cooke 4 Nov 1871 as #142 & #143).

This species with longitudinally striate ascospores is most closely related to *Lophiostoma viridiarum* Cooke, but differs in longer ascospores that have more transverse septa. It does not cause the bright green staining of substrate which typifies *L. viridiarum*. Fig. 119.

***magnifica*, (*Pleospora*)** Peck, Bull. Torrey Bot. Club 33: 221. 1906.

Type specimen (holotype): on stalks of *Phlox*, Silver Lake, Wasatch Co., Utah, 17 Aug 1905, A. O. Garrett, #745. Also issued as Fungi Columbiani #2258.

Wehmeyer (1961) considered this to be a doubtful species and possibly a mixture of two. Barr believes that it is a valid species, closely allied to *Pleospora negusensis* Bubak, Bot. Kozlem. 1915: 60. according to Wehmeyer's (1961) description of that taxon. For North American specimens which key to *P. njegusensis*, the name **Pleospora magnifica** Peck should be used.

***marciensis*, (*Sphaeria*)** Peck, Ann. Rep. New York State Mus. 31: 51. (for 1878) 1879.

Leptosphaeria marciensis (Peck) Sacc., Syll. Fung. 2: 80. 1883.

Type specimen (lectotype): on sterile sporophylls of *Lycopodium annotinum* Mt. Marcy, New York, Aug 1877, C. H. Peck; (syntype): on *Lycopodium selago*, Mt. Marcy, New York, Aug 1877, C. H. Peck (a duplicate of one of the collections on *L. selago* was sent to NY in 1935 and is at NY; also a duplicate of the same collection was sent to Ellis and is at NY).

Holm (1957) elucidated the distinguishing features of *Leptosphaeria lycopodina* (Mont.) Sacc. and *L. marciensis* (Peck) Sacc. Hedjaroude (1969) transferred *L. lycopodina* to *Phaeosphaeria*; *L. marciensis* also seems well placed in **Phaeosphaeria**, as **P. marciensis** (Peck) Holm & Holm, Karstenia 21: 68. 1981.

***marginalis*, (*Diaporthe*)** Peck, Ann. Rep. New York State Mus. 39: 52. Pl. 2, Figs. 1-5. (for 1885) 1887.

Melanconis marginalis (Peck) Wehm., Pap. Michigan Acad. I. 6: 382. 1926.

Melanconis alni Tul. var. *marginalis* (Peck) Wehm., The Genus *Melanconis*... p. 27. 1941.

Type specimen (holotype): on branches of *Alnus viridis*, Elizabethtown, Essex Co., New York, May 1885, C. H. Peck.

Wehmeyer (1941) noted that the conidial states of the European *M. alni* and the North American var. *marginalis* differ only in depth of pigmentation. Kobayashi (1970) considered that the difference in the conidial state was sufficient to recognize two species.

***megastoma*, (*Sphaerella*)** Peck, Bot. Gaz. 4: 231. 1879.

Physalospora megastoma (Peck) Sacc., Syll. Fung. 1: 437. 1882.

Type specimen (holotype): on living leaves of *Astragalus bisulcatus*, Colorado, July 1879, M. E. Jones. There is a disparity between the information in the protologue and that on the packet marked "type." The protologue states "Colorado, July" and the packet states "Utah, May." Unfortunately there is no surviving correspondence between Peck and Jones to clear this up. Two packets at NY, apparently received from Jones, are labelled *Sphaerella megastoma* Peck new species, Colorado Springs, June 11, 1879. One label is printed and is numbered Flora of Colorado 1573. Further, in the Marcus E. Jones herbarium (RSA) R. K. Benjamin has located two packets labelled as *Sphaerella megastoma* Peck, new species, collected at Colorado Springs, 11 June 1879 (Flora of Colorado 1573). Where the information on the packet at NYS (Utah, 8 May) came from remains a mystery. Dr. Rupert Barneby has identified the host material in the NY packets as *Astragalus bisulcatus*.

According to von Arx and Müller (1954) this is a synonym of **Polystigma astragali** (Lasch) v. Höhnel.

***melantera*, (*Sphaeria*)** (*Obtectae*) Peck, Ann. Rep. New York State Mus. 29: 62. (for 1875) 1878.

Type specimen (holotype): on branches of *Rubus strigosus*, Center (= Karner), Albany Co., New York, May, C. H. Peck.

Peck (Bull. Buffalo Soc. Nat. Sci. 4: 234. 1882) recognized that his species was synonymous with *Sphaeria hendersoniae* Ellis (Grevillea 6: 14. 1877). According to Ellis N.A.F. #581 and Peck's type specimen these names are both synonymous with *Melanomma coniothyrium* (Fuckel) Holm. The specimens agree with Holm's (1957) description of that species. In Barr's opinion, the fungus on *Rubus* is congeneric with *Diapleella clivensis* (Berk. & Br.) Munk on herbaceous stalks, and with the fungus on *Sambucus* known as *Dendropleella hirta* (Fries) Munk. For nomenclatorial reasons, *Dendropleella* is invalid. *Diapleella clivensis*, although described as having unitunicate asci, instead has bitunicate asci (slide of type ex K in UPS; IMI #15546 and others) and is a loculoascomycete. The genus name is utilized for species with soft ascomata, surrounded by narrow hyphae that may form a clypeus in substrate tissues, clavate asci in narrowly cellular pseudoparaphyses, and brown, fusoid, transversely septate ascospores. In *D. clivensis* ascospores are 15-22(-24) × 4.5-7 µm, in *M. coniothyrium* 12-15 × 3.5-5 µm. **Diapleella coniothyrium** (Fuckel) Barr, comb. nov. Basionym: *Sphaeria coniothyrium* Fuckel, Symb. Mycol. p. 115. 1870.

***melioloides*, (*Chaetomium*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 27: 106. (for 1873) 1875.

Type specimen (isotype): on old stalks of Indian corn, North Greenbush, Rensselaer Co., New York, Oct 1873, C. H. Peck. The first specimen accompanied by a small illustration sent to Cooke 28 Jan 1874 as #337 was "damaged in transportation." A second specimen #337 was sent at a later date. Both are at Kew. Peck originally named this species *C. divaricatum* in his notebooks but that name was never published.

Ames (1963) relegated Cooke and Peck's fungus to synonymy with **C. indicum** Corda. Fig. 120.

***minor*, (*Caryospora*)** Peck, Ann. Rep. New York State Mus. 44: 141 (reprint p. 29). (for 1890) 1891.

Type specimen (holotype): on hickory nut pericarp, Albany, Albany Co., New York, 1890, C. H. Peck.

Caryospora minor differs from *C. putaminum* (Schw.: Fries) de Not. in several respects, most obviously in ascospore shape, pigmentation, and septation. The species is now known as **Asteromassaria minor** (Peck) Barr, Mycotaxon 15: 376. 1982. Fig. 51.

***minutella*, (*Sphaeria*)** (*Caulicolae*) Peck, Ann. Rep. New York State Mus. 29: 62. (for 1875) 1878.

Physalospora minutella (Peck) Sacc., Syll. Fung. 1: 440. 1882.

Type specimen (holotype): on herbaceous stems, North Greenbush, Rensselaer Co., New York, June 1875, C. H. Peck.

The fungus is identical with **Phomatospora berkeleyi** Sacc., the type of the genus.

***minutella*, (*Valsa*)** Peck, Torrey Bot. Club 11: 27. 1884.

Engizostoma minutellum (Peck) O. Kuntze, Rev. Gen. Pl. 3: 474. 1898.

Type specimen (holotype): on bark of *Fagus ferruginea*, Canada, 1882, J. Macoun. #18.

Ellis and Everhart (1892) compared Peck's fungus with specimens of **valsa microspora** Cooke & Plowright, Grevillea 7: 82. 1879 [non *V. microspora* (Crouan) Sacc. 1882], and decided that they were identical.

***minutissima*, (*Sphaerella*)** Peck, Ann. Rep. New York State Mus. 40: 68. (for 1886) 1887, non *S. minutissima* Auersw. 1869.

Type specimen (holotype): on leaves of *Alnus incana*, Marcy Landing, Adirondack Mts., Essex Co., New York, June 1886, C. H. Peck.

This name is synonymous with **Venturia alnea** (Fr.) Müller, Sydowia 11:89. (1957) 1958.

***mirabilis*, (*Sphaeria*)** Peck, Ann. Rep. New York State Mus. 28:80. Pl. 2, Figs. 18-21. (for 1874) 1876.

Gnomoniella mirabilis (Peck) Sacc., Syll. Fung. 1: 414. 1882.

Gnomonia mirabilis (Peck) Monod, Sydowia Beih. 9:93. 1983.

Type specimen (holotype): on leaves of *Betula lutea*, Bethlehem, Albany Co., New York, June 1874, C. H. Peck.

This species is closely related to *Plagiostoma campylostylum* (Auers.) Barr, which also develops in leaves of *Betula*. The sizes of ascospores in *G. mirabilis* are larger. Horizontal perithecia with lateral ostioles, and ascospore shape, necessitated transferring Peck's species to **Plagiostoma** as **P. campylostylum** var. **mirabilis** (Peck) Barr, Mycol. Mem. 7: 116. 1978. Fig. 90 illustrates ascospores. Monod (1983) regards the fungus as a separate species in *Gnomonia*.

***monosperma*, (*Sphaeria*)** Peck, Ann. Rep. New York State Mus. 28: 79. Pl. 2, Figs. 36-39. (for 1874) 1876.

Julella monosperma (Peck) Sacc., Syll. Fung. 2: 289. 1883.

Type specimen (holotype): on decorticated *Betula* wood, Forestburgh, Sullivan Co., New York, Sept 1873, C. H. Peck.

The characteristics of the ascomata place the fungus in the Pleomassariaceae. By the septation of immature ascospores, a close relationship exists between *Sphaeria monosperma* and *Pleomassaria siparia* (Berk. & Br.) Sacc., which also occurs on *Betula*. The sizes and structure of ascomata and asci are similar, and *Sphaeria monosperma* could be visualized as a one-spored variant of *P. siparia*. It is now known as **Pleomassaria monosperma** (Peck) Barr, Mycotaxon 15: 372. 1982. Figs. 56, 57 illustrate the species.

***moroides*, (*Diatrype*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 26: 86. (for 1872) 1874 (*nomen nudum*); 29: 63. (for 1875) 1878.

Valsaria moroides (Cooke & Peck) Sacc., Syll. Fung. 1: 750. 1882.

Type specimen (isotype): on branches of *Alnus*, Sandlake, Rensselaer Co., New York, Sept 1871, C. H. Peck (portion sent to Cooke 5 March 1872 as #247).

Valsaria in the sense of *V. insitiva* (Tode: Fries) Ces. & de Not. is a member of the Amphisphaeriaceae, whereas *D. moroides* and some allied species are closer to the Diatrypaceae. Cooke and Peck's species was transferred to **Endoxylina** as **E. moroides** (Cooke & Peck) Shoemaker & Egger, Fungi Canad. 227. 1982. They provided a full description and illustrations. Figs. 79, 80 also illustrate the species.

***mucronata*, (*Valsa*)** Peck, Ann. Rep. New York State Mus. 28: 74. Pl. 2, Figs. 10-13. (for 1874) 1876.

Diaporthe mucronata (Peck) Sacc., Syll. Fung. 1: 629. 1882.

Type specimen (holotype): on branches of *Salix*, Sandlake, Rensselaer Co., New York, Sept 1874, C. H. Peck.

Wehmeyer (1933) considered the fungus synonymous with *Diaporthe tessella* (Pers.: Fr.) Rehm. This species has been segregated from *Diaporthe* as the type species of *Allantoporthe* Petrak, so that Peck's *V. mucronata* is a synonym of **Allantoporthe tessella** (Pers.: Fr.) Petrak, Hedwigia 62: 288. 1921 and Sydowia 24: 250. 1970 .

***mutans*, (*Sphaeria*) (*Villosae*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 26: 87. (for 1872) 1874; (*nomen nudum*); 29: 64. (for 1875) 1878.

Rosellinia mutans (Cooke & Peck) Sacc., Syll. Fung. 1: 259. 1882.

Type specimen (isotype): on decaying wood, Tyre, Seneca Co., New York, Sept 1871, C. H. Peck (portion sent to Cooke 24 Feb 1872 as #225).

This species of *Rosellinia* soon loses the thin tawny subiculum which Peck described. It appears to be related to *R. subiculata* (Schw.) Sacc. but in *R. mutans* the ostioles are umbilicate, while in *R. subiculata* they are papillate.

***mycetophila*, (*Nectria*)** Peck, Bull. Buffalo Soc. Nat. Sci. 1: 71. 1873; Ann. Rep. New York State Mus. 26: 85. (for 1872) 1874.

Nectriella mycetophila (Peck) Sacc., Syll. Fung. 2: 449, 450. 1883.

Type specimen (holotype): on decaying fungi, New Scotland, Albany Co., New York, Oct 1872, C. H. Peck.

As indicated by Samuels (1976) *Nectria mycetophila* is **Hypomyces aureonitens** Tulasne & Tulasne, Sel. Fung. Carp. IV 3: 60. 1865.

***myricae*, (*Metasphaeria*)** Peck, Ann. Rep. New York State Mus. 38: 105. Pl. 2, Figs. 24-27. (for 1884) 1885.

Massarina myricae (Peck) Berl., Icones Fung. 3: 66. 1902.

Type specimen (holotype): on branches of *Myrica gale*, Caroga, Fulton Co., New York, July 1884, C. H. Peck (now in two packets at NYS. A duplicate was sent to BPI in 1945).

This species agrees well with the concept of *Massarina* as delimited by Bose (1961). It possesses large ascomata and ascospores similar to *M. eburnea* (Tul.) Sacc., but differs in more nearly superficial, deeply depressed ascomata.

***neilliae*, (*Diaporthe*)** Peck, Ann. Rep. New York State Mus. 39: 52. Pl. 2, Figs. 6-9. (for 1885) 1887.

Type specimen (holotype): on branches of *Physocarpus* (*Neillia*, *Opulaster*) *opulifolius*, West Albany, Albany Co., New York, April 1885, C. H. Peck (duplicates sent to NY 1935 and is at NY, and BPI 1945).

According to Wehmeyer (1933) this is one of the many synonyms of **Diaporthe eres** Nits.

***nemopanthis*, (*Microsphaera*)** Peck, Ann. Rep. New York State Mus. 38: 102. (for 1884) 1885.

Type specimen (holotype): on leaves of *Nemopanthus canadensis*, Center (= Karner), Albany Co., New York, Sept 1884, C. H. Peck (now in two packets at NYS).

Salmon (1900) included this species among the synonyms of *Microsphaera alni* (Wallr.) Salmon; the earlier epithet is **M. penicillata** (Wallr.: Fr.) Lév., as noted by Cooke (1952).

***nigriceps*, (*Cordyceps*)** Peck, Bull. Torrey Bot. Club 27: 21. 1900.

Type specimen (holotype): "probably some subterranean fungus," among fallen pine leaves, Saco, Maine, 5 Nov 1899, C. L. Fox.

Mains (1957) reduced Peck's name to synonymy under **Cordyceps capitata** (Fr.) Link.

***nigrospora*, (*Diatrype*)** Peck, Ann. Rep. New York State Mus. 33: 33. (for 1879) 1883.

Valsaria nigrospora (Peck) Berl. & Vogl., Syll. Fung. Addit. 1-4: 129. 1886.

Melanconiella nigrospora (Peck) Dearness & House, Bull. New York State Mus. 266: 81. 1925.

Melanconis nigrospora (Peck) Wehm., Mycologia 32: 327. 1940.

Chapeckia nigrospora (Peck) Barr, Mycol. Mem. 7: 165. 1978.

Type specimen (holotype): on branches of *Betula lutea*, Quaker Street, Schenectady Co., New York, June 1879, C. H. Peck.

The definitely pseudoparenchymatous stromata which contain few perithecia segregate this fungus from all the others in the Melanconidaceae. Wehmeyer (1941) considered *M. nigrospora* atypical in the broad concept of *Melanconis* and suggested that it showed some affinities with *Valsaria*. However, *Valsaria* has a xylariaceous centrum, and is better considered as a member of the Amphisphaeriaceae. The genus *Chapeckia* was erected to accommodate Peck's species, and the name was coined to commemorate Peck's contribution to mycology. Figs. 101-103 illustrate *C. nigrospora*.

Wehmeyer (1941) included in the synonymy of *Melanconis nigrospora*: *Melanconis meschuttii* Ellis & Everh., Bull. Torrey Bot. Club 10: 117. 1883; *Melanconiella meschuttii* (Ell. & Ev.) Berl. & Vogl., Syll. Fung. Addit. 1-4: 129. 1886.

Valsaria niesslii (Wint.) Sacc., also occurs on *Betula* branches and has many similarities with *Chapeckia nigrospora*. However, in *V. niesslii* the pseudostroma is delimited by a black line in wood tissues, perithecia are not deeply immersed in stroma, asci are cylindric, stipitate, and ascospores are slightly smaller (9-12 × 3.5-4.5 μm) with short rounded appendages and apparent germ pore at each end.

***nuda*, (*Asterina*)** Peck, Ann. Rep. New York State Mus. 38: 102. Pl. 2, Figs. 11-15. (for 1884) 1885.

Asterella nuda (Peck) Sacc., Syll. Fung. 9: 397. 1891.

Cryptopus nudus (Peck) Theiss., Ann. Mycol. 12: 73. 1914.

Adelopus nudus (Peck) v. Höhnel, Sitzungsber. K. Akad. Wiss. Wien Math.-Nat. Kl. 127(1): 619. 1918.

Phaeocryptopus nudus (Peck) Petrak, Ann. Mycol. 36: 15. 1938.

Type specimen (holotype): on leaves of *Abies balsamea*, Aiden Lair, Adirondack Mts., Essex Co., New York, 1884, C. H. Peck (duplicate sent to NY 1935 and is at NY).

This species is the type of the genus *Phaeocryptopus* Petrak. It has been confused in the literature with *Meliola balsamicola* Peck (see discussion under that species).

***nuda*, (*Metasphaeria*)** Peck, Ann. Rep. New York State Mus. 44:141. (for 1890) 1891.

The type collection was not located at NYS and was noted as missing as early as 1905 in a NYS inventory by S. H. Burnham. The description of superficial perithecia with walls blue under the microscope suggests a species of *Gibberella*.

"Perithecia superficial, ovate or conical, submembranous, scattered or few collected together, black, the walls parenchymatous and blue under the microscope; asci about .003 inches long, .0005 broad; spores crowded or biseriate, fusiform, triseptate, colorless, .0007 to .0008 inches long, .00024 broad."

"Dead stems of millet, *Panicum miliaceum*, Menands. October. The species approaches *M. panicorum*, from which it is distinct by its superficial perithecia and shorter spores. The superficial character of the perithecia would remove the species to *Zignoella*, but the texture is not carbonaceous, and it has therefore been placed in *Metasphaeria*."

***obscura*, (*Valsa*)** Peck, Ann. Rep. New York State Mus. 28: 73, 74. (for 1874) 1876.

Diaporthe obscura (Peck) Sacc., Syll. Fung. 1: 627. 1882.

Apioporthe obscura (Peck) Wehm., Pap, Michigan Acad. Sci. I. 8: 219. 1928.

Type specimen (holotype): on stalks of *Rubus strigosus*, Albany, Albany Co., New York, May 1874, C. H. Peck.

Peck's fungus is a synonym of *Apioporthe vepris* (De Lacr.) Wehm., according to Wehmeyer (1933). However, Wehmeyer's concept of *Apioporthe* v. Höhnel differs from the original concept (which is the same as *Anisogramma* Theiss.). *Valsa obscura* belongs in *Cryptodiaporthe* as a synonym of **Cryptodiaporthe vepris** (De Lacr.) Petrak, Ann. Mycol. 32: 445. 1934.

***obtectum*, (Lophiostoma)** Peck, Ann. Rep. New York State Mus. 30: 65. (for 1876) 1878.

Lophidium obtectum (Peck) Sacc., Syll. Fung. 2: 713. 1883.

Type specimen (holotype): on branches of *Xanthoxylum americanum*, Bethlehem, Albany Co., New York, July 1876, C. H. Peck.

The ascospores are yellowish brown to dark brown, 25-32 × 7.5-10 μm, 5-7-septate, occasionally with a longitudinal septum in one or two cells. It is a synonym of **Lophiostoma pseudomacrostomum** Sacc.

***onosmodina*, (*Sphaeria*)** (*Caulicolae*) Peck & Clinton in Peck, Ann. Rep. New York State Mus. 30: 67. (for 1876) 1878.

Didymella onosmodina (Peck & Clint.) Sacc., Syll. Fung. 1: 555. 1882.

Type specimen (holotype): on stalks of *Onosmodium carolinianum*, Buffalo, Erie Co., New York, June 1876, G. W. Clinton.

The species is closely related to the type, *Didymella exigua* (Niessl) Sacc., but has ellipsoid rather than fusoid ascospores.

***opulifoliae*, (*Valsa*)** Peck, Ann. Rep. New York State Mus. 38:103. (for 1884) 1885.

Engizostoma opulifoliae (Peck) O. Kuntze, Rev. Gen. Pl. 3: 475. 1898.

Type collection (holotype): on branches of *Physocarpus* (*Spiraea*, *Opulaster*) *opulifolius*, West Albany, Albany Co., New York, 25 April 1884, C. H. Peck (duplicate sent to NY in 1935 and is at NY).

Barr found no fungus which agrees with Peck's description of *Valsa opulifoliae* on the type collection, but only *Diaporthe eres* Nits., of which *D. neilliae* Peck on the same host is a synonym.

***orbicula*, (*Venturia*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 25: 105. (for 1871) 1873.

Type specimen (lectotype designated here): on leaves of *Quercus montana*, Sandlake, Rensselaer Co., New York, May, C. H. Peck; (syntypes): on *Quercus*, Albany and Guilderland, New York.

The packet from Sandlake contains Peck's drawings and is therefore designated the lectotype. The only collection from Albany is Thümen's Exsiccata #855. Both collections represent the same species. No collection from Guilderland can be found at NYS. (An example of this species was sent to Cooke 22 May 1871 as #25. Its collection locality has not been checked by the authors.)

Saccardo (Syll. Fung. 1: 589. 1882) credited Cooke and Peck with making a new combination in *Venturia* of a species described by Schweinitz (*Sphaeria orbicula* Schw., Trans. Amer. Philos. Soc. II. 4: 224. 1832) and cited the name as "*Venturia orbicula* (Schw.) C. & P." Saccardo admitted that Peck did not cite the Schweinitz species but believed that the two species were not distinct. Nomenclaturally, the combination of the Schweinitz name in *Venturia* created a later homonym in *Venturia* and thus the name in *Venturia* must be *Venturia orbicula* Cooke & Peck and it must be lectotypified by one of the three collections cited by Cooke and Peck.

Venturia orbicula Cooke & Peck is a synonym of **Protoventuria quercina** (Pers.) Barr, Canad. J. Bot. 49: 1960. 1971 (see Barr 1968).

***orbicularis*, (*Sphaerella*)** Peck, Ann. Rep. New York State Mus. 28: 81. (for 1874) 1876.

Mycosphaerella orbicularis (Peck) House, Bull. New York State Mus. 233-234: 28. 1921.

Venturia orbicularis (Peck) Morelet, Soc. Fr. Phytopath. Travaux dedies a G. Viennot-Bourgin: 260. 1977.

Type specimen (lectotype): on leaves of *Populus grandidentata*, Center (= Karner), Albany Co., New York, May 1874, C. H. Peck; (syntype): North Greenbush, Rensselaer Co., New York, C. H. Peck (specimen not found at NYS) (a duplicate of the Center collection was sent to BPI in 1945).

Morelet (1983) discussed the history of various specific epithets and chose *V. orbicularis* as the oldest nonconfusing epithet for the taxon that has been referred to as *V. macularis* (Fr.) Müller & von Arx.

***osmundae*, (*Dothidea*)** Peck & Clinton in Peck, Ann. Rep. New York State Mus. 30: 64. (for 1876) 1878.

Dothidella osmundae (Peck & Clinton) Sacc., Syll. Fung. 2: 631. 1883.

Scirrhophragma osmundae (Peck & Clinton) Obrist, Phytopath. Z. 35: 377. 1959.

Scirrhia osmundae (Peck & Clinton) v. Arx in Müller & v. Arx, Beitr. Kryptogamenfl. Schweiz 11(2): 382. 1962.

as "(Peck & Curt.)". Holm & Holm, Bot. Not. 131:112. 1978.

Metameris osmundae (Peck & Clinton) von Arx & Müller, Stud. Mycol. 9: 80. 1875.

Type specimen (lectotype): on dead stems of *Osmunda*, Buffalo, Erie Co., New York, 1876, G. W. Clinton; (syntype): on petioles of *Osmunda*, Sandlake, Rensselaer Co., New York, June 1876, C. H. Peck (duplicates of both of the above collections were sent to NY in 1935 and both are in NY).

Obrist (1959) indicated one of the syntypes as type material thus effectively designating the Buffalo collection (NYS) as the lectotype. Both collections represent the same species.

Metameris osmundae has unusual ascospores, described and illustrated by Holm and Holm (1978). The uppermost 'cell' is devoid of cytoplasm and appears caplike, while the cytoplasmic cells may eventually become septate and light brown. These ascospores could be likened to those of species of *Paraphaeosphaeria*, although ascomata differ. The European entity, *Scirrhophragmia regalis* Theiss.& Sydow, is identical with that from North America. *Metameris iaponica* Theiss. & Sydow has smaller stromata with fewer locules and larger ascospores, and may be a separate species (Holm and Holm 1978).

oxyspora, (*Valsa*) Peck, Ann. Rep. New York State Mus. 28: 73. Pl. 2, Figs. 26-29. (for 1874) 1876.

Diaporthe oxyspora (Peck) Sacc., Syll. Fung. 1: 627. 1882.

Type specimen (holotype): on *Nemopanthus*, Sandlake, Rensselaer Co., New York, Aug 1874, C. H. Peck.

The description gives the substrate as oak branches; according to annotations by House, the host is *Nemopanthus mucronatus*.

Wehmeyer (1933) recognized this as a valid species of *Diaporthe*.

pannosa var.*ribis*, (*Sphaerotheca*) Peck, Ann. Rep. New York State Mus. 39: 58. (for 1885) 1887.

Type specimen (holotype): on stalks, fruit and leaves of *Ribes cynosbati*, Bergen, Genesee Co., New York, June 1885, C. H. Peck (A duplicate is at NY.). Peck also mentions receiving specimens from Colorado.

Salmon (1900) did not dispose of this variety. According to the description, it belongs in **Sphaerotheca mors-uvae** (Schw.) Berk. & Curt.

parasitica var. *caespitosa*, (*Barya*) Peck, Ann. Rep. New York State Mus. 43: 79, 80. (for 1889) 1890.

Type specimen (holotype):on *Bertia moriformis*, on decaying wood of *Fagus*, Catskill Mts., New York, Sept, C. H. Peck (now in two packets at NYS).

The perithecia of this variety of the species are closely grouped over the substrate. Microscopically, var. *caespitosa* is similar to **Barya parasitica** Fuckel var. **parasitica** (Barr in Bigelow and Barr 1963).

parasitica, (*Lophiotrema*) Peck, Ann. Rep. New York State Mus. 40: 71. (for 1886) 1887.

Lophiostoma angustilabrum var.*parasiticum* (Peck) Chesters & Bell, Mycol. Pap. 120: 9. 1970.

Type specimen (holotype): on old *Hypoxylon morsei* on *Alnus*, Elizabethtown, Essex Co., New York, Sept 1886, C. H. Peck (duplicate sent to NY 1935 and is at NY).

This specimen has ascomata whose apical papilla may be rounded, compressed, or triangular, and the apical opening is rounded or slit-like. It is a variant of **Pseudotrichia mutabilis** (Pers.: Fr.) Wehm. Fig. 121.

parnassiae, (*Sphaeria*) Peck, Ann. Rep. New York State Mus. 27: 111. (for 1873) 1875.

Didymosphaeria parnassiae (Peck) Sacc., Syll. Fung. 1: 703. 1882.

Microthelia parnassiae (Peck) O. Kuntze, Rev. Gen. Pl. 3: 498. 1898.

Type specimen (holotype): on stalks of *Parnassia caroliniana* (*P. glauca*), Albany, Albany Co., New York, Sept 1873, C. H. Peck.

The type specimen is in poor condition, the ascomata either immature or with asci and ascospores shrivelled. The few ascospores recognizable were fusoid, yellow brown, 6-septate. According to Peck's description, they measured 37-40 μm long. Evidently the fungus is a **Nodulosphaeria**, perhaps **N. modesta** (Desm.) Munk. Fig. 122.

parvula, (Uncinula) Cooke & Peck, J. Bot. II. 10: 170, 171. 1872.

Type: on leaves of *Celtis occidentalis*, Poughkeepsie, Dutchess Co., New York, W. R. Gerard (not located in Peck herbarium; portion sent to Cooke 20 Dec 1871 as #189).

Salmon (1900) recognized this as a valid species.

patella, (*Hypocrea*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 57. (for 1875) 1878.

Type specimen (lectotype): on decaying wood, Buffalo, New York, March, G. W. Clinton; (syntype): same data but collected in April.

In the packet at NYS marked TYPE are three small packets plus two cards bearing the fungus. One of the small packets bears the data "4 March 10, sent to Cooke"; another is labelled "21 April 18, sent to Cooke" (Peck's notebooks indicate this was sent 21 Feb 1872 as #211. This specimen plus a small drawing by Peck are at Kew);

the third has "21 April 18" only. The "April" collections as well as the two on cards without data are all the same fungus.

Hypocrea patella is retained as a distinct species.

***paucispora,* (*Valsa*)** Peck, Ann. Rep. New York State Mus. 33: 33. (for 1879) 1883.

Cryptosporella paucispora (Peck) Berl. & Vogl., Syll. Fung. Addit. 1-4: 70. 1886; Syll. Fung. 9: 609. 1891.

Cryptospora paucispora (Peck) Ellis & Everh., N. Amer. Pyrerenomyc. p. 529. 1892.

Type specimen (holotype):on branches of *Alnus*, North Greenbush, Rensselaer Co., New York, May 1879, C. H. Peck.

Reid and Cain (1960) published a full description and illustrated **Cryptosporella paucispora.**

***penicillata* var.*alni*, (*Microsphaera*)** (Tul.) Cooke & Peck, J. Bot. II. 10: 171. 1872.

Erysiphe alni Tul., Sel. Fung. Carp. 1: 263. 1861.

Peck had specimens on *Alnus* from Greenbush, Rensselaer Co., and from Buffalo, Erie Co., New York

The variety is **Microsphaera penicillata** (Wallr.: Fr.) Lév. var. **penicillata**, according to W. B. Cooke (1952).

***petiolophila,* (*Sphaeria*)** Peck, Ann. Rep. New York State Mus. 35: 144, 145. (for 1881) 1884.

Gnomonia petiolophila (Peck) Berl. & Vogl., Syll. Fung. Addit. 1-4: 90. 1886; Syll. Fung. 9: 674. 1891.

Cryptodiaporthe petiolophila (Peck) Barr, Mycol. Mem. 7: 136. 1978.

Type: on petioles of *Acer spicatum*, Helderberg Mts., May. Fig. 123. The type has not been located at NYS and was noted as missing in a herbarium inventory by S. H. Burnham in 1905. There is another Peck collection on petioles of *Acer spicatum*, Adirondack Mts., New York, June 1880?, C. H. Peck.

Ascospores are illustrated in Fig. 97. In addition to the specimen at NYS, there is another collection on *Acer spicatum*, Karner, Albany Co., New York, 11 April 1914, H. D. House, and one on *Acer saccharum*, Oneida, Otsego Co., N.Y., 15 May 1918, H. D. House.

***phaeostromoides,* (*Sphaeria*)** Peck, Ann. Rep. New York State Mus. 28: 77. Pl. 2, Figs. 30-35. (for 1874) 1876.

Chaetosphaeria phaeostromoides (Peck) Sacc., Syll. Fung. 2: 93. 1883.

Chaetosphaeria phaeostroma var. *phaeostromoides* (Peck) Ellis & Everh., N. Amer. Pyrenomyc. p. 160. 1892.

Type specimen (holotype): on decorticated branches of *Acer*, North Greenbush, Rensselaer Co., New York, Sept 1874, C. H. Peck.

As Hughes and Hennebert (1963) stated, Peck's fungus is identical with *Thaxteria fusca* (Fuckel) Booth. On the type specimen the conidial state, *Oedemium didymum* (Schm.) Hughes, is also present. Müller in Kendrick (1971), observed that *Thaxteria fusca* as well as *T. phaeostroma* (Dur. & Mont.) Booth differed from the type species of the genus, *T. didyma* Speg. *Thaxteria fusca* is now included in the genus **Chaetosphaerella**, as **C.fusca** (Fuckel) Müller & Booth, Trans. Brit. Mycol. Soc. 58: 77. 1972.

***phileura,* (*Sphaeria*)** (*Pertusae*) Cooke & Peck in Cooke & Ellis, Grevillea 5: 55. 1876.

Amphisphaeria phileura (Cooke & Peck) Sacc., Syll. Fung. 1: 725. 1882.

Type specimen (isotype): on bark of *Tilia americana*, Helderberg Mts., New York, C. H. Peck (this is possibly the collection sent to Cooke 28 March 1972 as #267 labeled "*Sphaeria citrispora*?").

Sphaeria phileura, *S. recessa* and *S. thujina* are three taxa in the complex of *Microthelia applanata*. Hawksworth (pers. comm.)is revising the species described as *Microthelia* and (1985) has segregated *Sphaeria recessa* and *S. thujina* into the new genus **Kirschsteiniothelia.** *Sphaeria phileura* also belongs in this genus, and appears to be a diminutive form of **K. aethiops** (Berk. & Curt.) Hawksworth (Bot. J. Linn. Soc. 89: 000. 1985). Barr's information from the isotype specimen of *Sphaeria phileura* is summarized below. Fig. 50.

Ascomata applanate and conic, 170-400 μm diam, 110-240 μm high, bases attached to substrate, separate or few grouped, with short broad apical papilla; wall of numerous layers of small cells, thin-walled 10-15 μm and light brown at base, 20-33 μm wide and dark brown at sides. Asci 46-66 × 13-18 μm bitunicate, oblong, base foot-like; pseudoparaphyses numerous. Ascospores 15.5-21 × 6.5-8.5 μm bright or dull brown, ellipsoid or obovoid, apex rounded, more tapered to base, 1-septate, submedian, constricted, one large globule or minute guttules in each cell, wall thick, dark, finely roughened, overlapping biseriate in the ascus.

pinea (Caliciopsis) Peck, Bull. Torrey Bot. Club 9: 62. May, 1882.

Type specimen: on bark of living pine trees, Charlotte, Chittenden Co., Vermont, March 1879, C. G. Pringle #300. According to Fitzpatrick (1920) two other portions of Pringle's collection exist, one in the Farlow Herbarium (FH) and one as #1741 in Fitzpatrick's Herbarium at CUP. The NYS collection in the Peck Herbarium is hereby chosen as lectotype.

The place of publication and the identity of the type collection of this species have been misinterpreted in the past. Peck published the description of the genus *Caliciopsis* and its single species in two different places: the Ann. Rep. New York State Mus. 33: 32. Pl. 2, Figs. 11-15. (for 1879) and the Bull. Torrey Bot. Club, vol. 9, issue #5, May 1882. What subsequent authors (Fitzpatrick 1920) had not taken into account was the actual dates of the publication of these two articles. The Bull. Torrey Bot. Club article was published in May 1882 but the Ann. Rep. New York State Mus. for 1879 was not released until June 1883. This would ordinarily be a minor technical point but Peck cited different specimens in the two publications. It appears that Peck anticipated the delay in the publication of his Museum Report and intended the Torrey Bulletin to be the validating publication of his new species and genus. The title of his article is "New Species of Fungi" and "Gen. nov." follows the first use of the genus *Caliciopsis* in the Bull. Torrey Bot. Club. The type is therefore the Pringle collection mentioned in the Bulletin of the Torrey Botanical Club and not the Peck collections from Charlton, New York and Guilderland, New York which were mentioned in the Museum Report. The Guilderland collection has not been located in the Peck Herbarium.

The species is the type of the genus *Caliciopsis* Peck.

***platasca*, (*Diatrype*)** Peck, Ann. Rep. New York State Mus. 27: 109. (for 1873) 1875.

Diaporthe platasca (Peck) Sacc., Syll. Fung. 1: 613. 1882.

Diaporthella platasca (Peck) Wehm., The Genus *Diaporthe*... p. 217. 1933.

Type specimen (holotype): on branches of *Betula*, Nipple Top Mt., Adirondack Mts., Essex Co., New York, Aug 1873, C. H. Peck.

This species is close to **Diaporthella aristata** (Fr.) Petrak, the type of the genus. The latter fungus also occurs on *Betula* in Europe. Barr (1978) concluded that they are synonymous. Fig. 124.

***platascum*, (*Cenangium*)** Peck, Bot. Gaz. 4: 231. 1879.

Dothiora platasca (Peck) Sacc., Syll. Fung. 8: 766. 1889.

Blitrydium platascum (Peck) Sacc., Syll. Fung. 8: 806. 1889. (as "platyascum").

Triblidium platascum (Peck) O. Kuntze, Rev. Gen. Pl. 3: 537. 1898.

Type specimen (holotype): on bark, Alabama, 1879, T. M. Peters (small duplicate sent to CUP-D).

The fungus is **Myriangium duriaei** Mont. & Berk. in Berk., J. Bot. London 4: 73. 1845.

***polymorpha* var.*combinans*, (*Xylaria*)** Peck, Bull. New York State Mus. 116: 33. 1907.

Type specimen (holotype): on roots of dead *Acer*, Bridgeport, Fairfield Co., Connecticut, 28 Nov 1906, P. W. Graff.

Peck based the variety on the caespitose grouping of subglobose stromata.

***polyporinus*, (*Hypomyces*)** Peck, Bull. Buffalo Soc. Nat. Sci. 1: 71. 1873; Ann. Rep. New York State Mus. 26: 84. (for 1872) 1874.

Peckiella polyporinus (Peck) Sacc., Syll. Fung. 9: 945. 1891.

Hypolyssus polyporinus (Peck) O. Kuntze, Rev. Gen. Pl. 3: 488. 1898.

Type specimen (lectotype): on *Polyporus versicolor*, East Worcester, Otsego Co., New York, July 1872, C. H. Peck.

In the protologue published in 1873 Peck listed two localities: Worcester, Otsego Co., July 1872, and Croghan, Lewis Co., Sept 1872, New York. No specimens from Croghan (= Felt House) can be located in NYS. Seaver (1910) cited Worcester as the type locality and thus in effect chose that collection as the lectotype. The description and data for the new species published in 1874 are identical except that the locality, "Richmondville, Schoharie Co.", has been inserted as well as a note that the species was found in three distinct localities in one season. Ample material labelled from Richmondville and identified by Peck is present at NYS: it agrees in all respects with the lectotype. **Hypomyces polyporinus** is a distinct species. Fig. 125.

***pontederiae*, (*Sphaerella*)** Peck, Ann. Rep. New York State Mus. 40: 69. (for 1886) 1887.

Mycosphaerella pontederiae (Peck) House, Bull. New York State Mus. 233-234: 29. 1921.

Type specimen (holotype): in spotted areas of leaves of *Pontederia cordata*, Whitehall, Washington Co., New York, Sept 1886, C. H. Peck (a duplicate was sent to BPI in 1945).

Sphaerella paludosa Ellis & Everh., N. Amer. Pyrenomyc., P. 294. 1892, is a synonym of **Mycosphaerella pontederiae.**

***pringlei*, (*Dothidea*)** Peck, Bot. Gaz. 7: 57. 1882.

Auerswaldia pringlei (Peck) Sacc., Syll. Fung. 2: 626. 1883.

Sphaerodothis pringlei (Peck) Theiss. & Sydow, Ann. Mycol. 13: 579. 1915.

Type specimen (holotype): on leaves of *Yucca macrocarpa*, Santa Rita Mts., Arizona, 3 May 1881, C. G. Pringle, #781.

Petrak recognized that this fungus has a sphaeriaceous centrum and erected the genus **Apodothina** Petrak (Sydowia 23: 276. 1969. [1970]). with **A. pringlei** (Peck) Petrak (p.277) as the type species.

prominens, (***Lophiostoma***) Peck, Ann. Rep. New York State Mus. 31: 50. (for 1877) 1879.

Navicella prominens (Peck) O. Kuntze, Rev. Gen. Pl. 3: 500. 1898.

Type specimen (holotype): on branches of *Cephalanthus occidentalis*, Center (= Karner), Albany Co., New York, June 1877, C. H. Peck.

According to Berlese (1890), Peck's fungus is identical with *Lophiostoma caudatum* Fabre. However, Chesters and Bell (1970) described *L. caudatum* with pyriform or clavate ascospores. **Lophiostoma prominens** is close to *L. caulium* (Fr.) Ces. & de Not. but is retained as a separate species because of larger ascomata and broader ascospores, 21-24(-42) × 6-8 μm.

prosopidis, (***Rhytidhysterium***) Peck, Ann. Rep. New York State Mus. 46: 39-40. (for 1892) 1893.

Type specimen (holotype): on *Prosopis juliflora*, Austin, Texas, 24 Nov 1891, L. M. Underwood (small duplicate at CUP-D). Two duplicates are at NY, one from Underwood and one from Underwood via Earle.

The fungus is **Rhytidhysteron rufulum** (Spreng.: Fr.) Petrak, Sydowia 5: 186. 1951.

pruinosa, (***Sphaerotheca***) Cooke & Peck, J. Bot. II. 10: 11. 1872; Ann. Rep. New York State Mus. 25: 94 (for 1871) 1873; 43: 86. (for 1889) 1890.

Albugo pruinosa (Cooke & Peck) O. Kuntze, Rev. Gen. Pl. 3: 442. 1898.

Type specimen (isosyntype): on leaves of *Rhus glabra*, Greenbush, Rensselaer Co., New York, Aug 1870, C. H. Peck. (A portion of this collection was sent to Cooke 10 Nov 1871, and a second portion sent 13 May 1872. A duplicate was sent to NY in 1935). The protologue also mentions a second collection; New York W. W. D. (Denslow?), #47, which is not at NYS.

The fungus was made a synonym of *Sphaerotheca humuli* (DC.) Burrill by Salmon (1900); the earlier epithet is *S. macularis* (Wallr.: Fr.) Lind. According to annotation on the NY duplicate, Braun accepts *S. pruinosa*.

prunicola, (***Valsa***) Peck, Ann. Rep. New York State Mus. 33: 33, 34. (for 1879) 1883.

Diaporthe prunicola (Peck) Wehm., The Genus *Diaporthe*.... p. 126. 1933.

Type specimen (holotype): on branches of *Prunus pensylvanica*, Sandlake, Rensselaer Co., New York, May 1879, C. H. Peck.

pulchella, (***Venturia***) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 25: 106. (for 1871) 1873.

Gibbera pulchella (Cooke & Peck) Petrak, Sydowia 1: 200. 1947.

Stigmatea pulchella (Cooke & Peck) Barr, Canad. J. Bot. 46: 828. 1968.

Type specimen: on leaves of *Chamaedaphne calyculata*, Center (= Karner), Albany, New York, April 1871, C. H. Peck.

The packet at NYS bears on the outer label the dates "November 1871 to June 1872" in H. D. House's hand but Peck's original label states "April" and in the description he noted that fertile specimens were obtained in April. (The years stated by House appear to be one year too recent as a portion of this was sent to Cooke 5 June 1871 as collection #32 with the name *Venturia cassandrae* n. sp. A duplicate was sent to BPI in 1945).

In accordance with B. Eriksson's (1974) use of *Pyrenobotrys* for species previously referred to *Stigmata* (see *compacta*), the combination of **Pyrenobotrys pulchella** (Cooke & Peck) Barr, comb. nov., is proposed.

pulchra, (***Microsphaera***) Cooke & Peck, J. Bot. II. 10: 12. 1872; Ann. Rep. New York State Mus. 25: 95. (for 1871) 1873.

Type specimen (isotype): on leaves of *Cornus alternifolia*, N. Greenbush, Rensselaer Co., New York, Sept 1870, C. H. Peck (portion sent to Cooke 10 Nov 1871 as #155; a duplicate was sent 3 May 1872 and received Sept 1872; a further portion was sent to Plowright. These plus one other collection matching the type information are at K).

This is a synonym of *Microsphaera alni* (Wallr.) Salmon (1900); the earlier epithet is **M. penicillata** (Wallr.: Fr.) Lév. var. **penicillata** (W. B. Cooke 1952).

pulchriseta, (***Sphaeria***) (*Villosae*) Peck, Ann. Rep. New York State Mus. 31: 50. (for 1877) 1879.

Acanthostigma pulchrisetum (Peck) Sacc., Syll. Fung. 2: 208. 1883.

Eriosphaeria pulchriseta (Peck) Sacc., Syll. Fung. 2 (Addenda): xlvii. 1883; Syll. Fung. 9: 698. 1891.

Trichosphaeria pulchriseta (Peck) Ellis & Everh., N. Amer. Pyrenomyc. p. 151. 1892.

Lohwagiella pulchriseta (Peck) Petrak, Sydowia 23: 280. (1969) 1970.

Type specimen (holotype): on poplar chips, Griffins, Delaware Co., New York, Sept 1877, C. H. Peck. A second collection in NYS, on maple chips, Griffins, C. H. Peck, is identical, as is Ellis & Everh. N.A.F. #3218 of *Trichosphaeria pulchriseta*.

Petrak based the genus *Lohwagiella* on Peck's species, and noted that it differed from *Trichosphaeria* by very small perithecia, with no sign of ostiole. Barr's examination of the type specimen revealed a minutely papillate ostiole and periphysate apical canal, and ascospores which eventually become one-septate. The species appears to be a good **Niesslia**, **N. pulchriseta** (Peck) Barr, comb. nov. (Figs. 67-69). It can be distinguished from *N. exilis* (Alb. & Schw.: Fr.) Wint. by smaller ascospores 5.5-7.5 × 1-1.5(-2) μm vs. 8-13 × 1.5-2.5 μm and by habitat on wood fragments, rather than dead leaves of various plants.

pulviniceps, (***Valsa***) Peck, Ann. Rep. New York State Mus. 32: 50. (for 1878) 1880.

Cryptospora pulviniceps (Peck) Sacc., Syll. Fung. 9: 940. 1891.

Anthostoma pulviniceps Peck in Ellis & Everh., N. Amer. Pyrenomyc. p. 578. 1892.

Type specimen (holotype): (now in 2 packets) on *Sambucus canadensis*, Richmondville, Schoharie Co., New York, Sept 1877, C. H. Peck.

The type description is a composite one based on perithecia of the diatrypaceous host fungus, and asci and ascospores of the hypersaprobe. The latter is a form of **Berlesiella nigerrima** (Blox.) Sacc. (Barr in Bigelow and Barr 1969).

purpurea, (***Valsaria***) Peck, Bull. Torrey Bot. Club 11: 28. 1884.

Type specimen (holotype): on bark of *Fraxinus*, Belleville, Ontario, Canada, 1882, J. Macoun.

On the type packet the host was first "oak," then described as ash, later determined to be *Tilia americana*.

The type specimen appears to be identical in all respects with **Valsaria exasperans** (Gerard) Sacc., Syll. Fung. 2: 1v. 1883, as J. Dearness had noted in the type packet.

purpureus, (***Hypomyces***) Peck, Bull. Torrey Bot. Club 25: 327. 1898.

Type specimen (holotype): apparently parasitic on some species of *Lactarius*, Pennsylvania, Aug 1897, C. McIlvaine.

As indicated by Seaver (Mycologia 2: 72. 1910) *H. purpureus* is a synonym of **Hypomyces lactifluorum** (Schw.: Fr.) Tulasne, Ann. Sci. Nat. Bot. IV. 13: 11. 1860.

pusilla, (***Patellaria***) Peck, Ann. Rep. New York State Mus. 32:48. (for 1878) 1880.

Lecanidion pusillum (Peck) Sacc., Syll. Fung. 8: 799. 1889.

Type specimen (holotype): on decaying beech wood, Catskill Mts., New York, July 1878, C. H. Peck (small duplicate in CUP-D).

This is a form of *Corynella atrovirens* (Pers.: Fr.) Boud. in the Helotiales, which is now **Claussenomyces atrovirens** (Pers.: Fr.) Korf & Abawi, Canad. J. Bot. 49: 1882. 1971.

quercina, (***Ascomycetella***) Peck, Bull. Torrey Bot. Club 8: 50. 1881.

Cookella quercina (Peck) Sacc., Syll. Fung. 8: 846. 1889. (as *Cookella quercina* Peck).

Type specimen (holotype): on living leaves of *Quercus tinctoria*, Cobden, Union Co., Illinois, Sept & Oct, F. S. Earle. (The date, 24 Oct 1882, which is written on the packet in Homer House's hand is apparently in error as a description in the packet is dated 7 June 1880.).

This species is the type of *Ascomycetella* Peck and the genus is synonymous with *Cookella*, according to von Arx (1963). Peck's fungus is **Cookella microscopica** Sacc.

racemula, (***Sphaeria***) (*Caulicolae*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 26: 87. (for 1872) 1874 (*nomen nudum*); 29: 65. (for 1875) 1878.

Diaporthe racemula (Cooke & Peck) Sacc., Syll. Fung. 1:691. 1882.

Ditopellopsis racemula (Cooke & Peck) Barr, Mycol. Mem. 7: 91. 1978.

Cryptodiaporthe racemula (Cooke & Peck) Monod, Sydowia Beih.9: 210, 1983.

Type specimen (isotype): on stalks of *Epilobium angustifolium*, Lower Ausable Lake, Adirondack Mts., Essex Co., New York, July 1871, C. H. Peck (portion sent to Cooke 10 April 1872 as #276); an additional collection in the Peck herbarium, Aiden Lair, Adirondack Mts., Essex Co., New York, undated, C. H. Peck, was probably made at a later date as there is no record of Peck collecting at that location before 1884. Additional specimens: Katahdin Stream Campground, Baxter State Park, Maine, 5 Sept 1962, Barr 3759 (MASS). Wehmeyer (1933) collected the species in Nova Scotia. Figs. 94-96 illustrate *Ditopellopsis racemula*.

Monod (1983) included *Ditopellopsis clethrae* Reid & Booth (Canad. J. Bot. 45: 1479. 1967), the type species of the genus, in *Gnomonia* and reduced *Ditopellopsis* to synonymy with *Gnomonia*. He transferred *Ditopellopsis racemula* to *Cryptodiaporthe*, but Barr prefers to retain *Ditopellopsis* as a separate genus which includes *D. racemula*.

ramulicola, (***Sphaeria***) Peck, Ann. Rep. New York State Mus. 25: 104. (for 1871) 1873.

Leptosphaeria ramulicola (Peck) Sacc., Syll. Fung. 2: 26. 1883.

Type specimen (holotype): on twigs of *Ulmus americana*, Greenbush, Rensselaer Co., New York, May 1871, C. H. Peck.

Additional collections include Barr 3161 and 6658 from Massachusetts. The ascospores in the type collection may be one celled or septate; in Barr's collections they are usually one septate, but 6658 had some ascospores with two, four, or six additional transverse septa and even at times a longitudinal septum in some cells. This variability posed problems in disposing of the species until several taxa with similar ascomata and centra were compared. The associated coelomycetous anamorph provided another hint. Together these features suggested close relationhship with *Botryosphaeria*. The ascospores of these taxa, including *Sphaeria ramulicola*, are rich dark brown and septate, in contrast to those of *Botryosphaeria*. *Neodeightonia* Booth (in Punithalingham, Mycol. Pap. 119: 17. 1969) seems separable from *Botryosphaeria* by the ascospore pigmentation and septation. The combination in *Neodeightonia* is proposed.

Neodeightonia ramulicola (Peck) Barr, comb. nov. Figs. 23-25.

Ascomata erumpent in groups, black, globose or slightly depressed, 330-440 μm diam, apex rounded, very short papillate, seated in subiculum of blackish, branched and anastomosed hyphae, 3-6 μm wide; ascomal wall thick, 50-104 μm, wide, of large pseudoparenchymatic cells, often thick walled and sclerotial, blackened externally, reddish brown internally, with layers of small hyaline cells surrounding locule. Asci 110-130 × 15-30 μm, bitunicate, clavate cylindric, base short stipitate and foot-like; pseudoparaphyses cellular. Ascospores (18-) 25-31 × 12-13 μm, brown, oblong, obovoid, subglobose at times, (0-)1-2-septate, not constricted at septa, one globule in each cell, wall smooth or finely roughened, minute germ pore area visible at ends, surrounded by remnants of gel coat, overlapping biseriate in the ascus.

Two pycnidial fungi occur on the branches: 1) Pycnidia similar to ascomata but smaller, interior wall lined by short conidiophores; conidia 16-17 × 10 μm, brown, ovoid, 0- or 1-septate. 2) Pycnidia small, 117-140 μm, wall of layers of small cells, lined by short conidiophores; conidia 18-22 × 4-5.5 μm, dull brown, narrowly ellipsoid fusoid, 0-5(-8)-septate. This second pycnidial fungus does not appear to have any connection with *Neodeightonia ramulicola* but rather is a saprobe of later incidence.

***recessa*, (*Sphaeria*)** (*Denudatae*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 61. (for 1875) 1878.

Melanopsamma recessa (Cooke & Peck) Sacc., Syll. Fung. 1: 579. 1882.

Type specimen (isotype): on decaying wood, Tyre, Seneca Co., New York, Sept 1871, C. H. Peck (portion sent to Cooke 4 Nov 1871 as #141).

A second collection in NYS under this name (on wood of *Acer rubrum*, Verona, Oneida Co., New York, Aug, C. H. Peck) has hyaline ascospores which become brown in age, but these are longer, 27.5-33 × 7.5-9 μm, and this collection is a form of *Trematosphaeria pertusa* (Pers.: Fr.) Fuckel.

The ascospores of *Sphaeria recessa* were described as hyaline and 15-21 × 6.5-11 μm, but they are brown and smaller. Applanate ascomata and brown somewhat asymmetric ascospores of the type collection suggest the genus *Microthelia*. As indicated under *Sphaeria phileura*, **Kirschsteiniothelia** accommodates similar species, and this one is **K. recessa** (Cooke & Peck) Hawksworth, Bot. J. Linn. Soc. 89: 195. Figs. 47-49. Von Hohnel (1919) suggested the genus name *Amphisphaerina* for *Sphaeria recessa* and a few other supposedly hyaline-spored species, but he did not typify the genus nor transfer any species to it. Hawksworth (1985) lectotypfied *Amphisphaerina* and synonymized it under Arthopyrenia.

***rhodospiloides*, (*Herpotrichia*)** Peck, Bull. Torrey Bot. Club 36: 154, 155. 1909.

Type specimen (holotype): on wood of *Populus deltoides*, Batesville, Independence Co., Arkansas, 7 Oct 1908, E. Bartholomew. Also distributed as Fungi Columbiani #2835.

This has been considered to be a synonym of *H. rhodosticta* (Berk. & Br.) Sacc. (Syll. Fung. 2: 213. 1883) by Bose (1961), Müller and von Arx (1962) and Sivanesan (1971). Peck's fungus is indeed identical with *H. rhodosticta*. Both names are synonymous with **Byssosphaeria rhodomphala** (Berk.) Cooke.

***rimincola*, (*Dothidea*)** (Schw.) Peck, Ann. Rep. New York State Mus. 30: 64. (for 1876) 1878.

Hysterium rimincolum Schw., Trans. Amer. Philos. Soc. II. 4: 244. 1832.

According to Peck's specimen (on twigs of *Diervilla trifida*, Buffalo, Erie Co., New York, G. W. Clinton) and a portion of Schweinitz's type in NYS, this is **Dothiora rimincola** (Schw.) Barr, Contr. Univ. Michigan Herb. 9: 573. 1972.

***robusta*, (*Diaporthe*)** Peck, Ann. Rep. New York State Mus. 48: 114 (for 1894) 1897.

Type specimen (lectotype): on branches of *Acer saccharum*, Gansevoort, Saratoga Co., New York, Sept 1894, C. H. Peck; (syntype): on dead branches of *Acer*, Alcove, Albany Co., New York, Nov 1893, C. L. Shear.

Wehmeyer (1933) included Peck's fungus under the name **Diaporthe dubia** Nits. He examined the Gansevoort collection and designated it as "type." The original label used *robusta* as a variety of *Diaporthe acerina* (Pk.) Sacc., but that combination was not published.

***rubefaciens*, (*Sphaeria*)** Peck, Ann. Rep. New York State Mus. 28: 217. 1882. (for 1874) 1876.

Ceratostoma rubefaciens (Peck) Sacc., Syll. Fung. 1: 217. 1882.

Type specimen (lectotype): on decorticated wood of deciduous trees, Forestburgh, Sullivan Co., New York, Sept 1873, C. H. Peck.

In the description two collections (syntypes) are given: Forestburgh, Sept; Buffalo, Clinton. Only the Forestburgh collection can be found at NYS and it is hereby designated lectotype.

The small dark reddish brown ascospores in small asci, contained in beaked, carbonaceous ascomata, are much like those in *Rhynchostoma*, although in *R. minutum* Karst. the ascospores are one septate. *Rhynchostoma rubrocinctum* Karst. has a reddish tip to the beak; here the tip is pallid when discharged ascospores are removed. By the spiral ornamentation of one-celled ascospores, Peck's species is distinctive.

Rhynchostoma rubefaciens (Peck) Barr, comb. nov. Figs. 60-62.

Perithecia scattered on and bases embedded in reddened decorticated wood, globose depressed, 190-330 μm diam, 165-220 μm high, ostioles elongate, 330-550 μm or longer, 40-65 μm wide near base, tapering to apex, irregular or branched at times, canal periphysate, often crowned with mass of discharged ascospores; wall of narrow parallel to interwoven hyphae, reddish brown, ostiole externally bearing narrow gel layer. Asci 15-20 × 6-7 μm, unitunicate, oblong or ovoid, short stipitate, wall thin and delicate, deliquescing, without apical annulus; paraphyses narrow. Ascospores 5-6.5 × 2.5-3 μm, reddish brown, darker after discharge, ellipsoid or ovoid, 1-celled, usually 3 minute globules, wall dark except for minute germ pore in more tapered end, ornamented with parallel spiral ridges, crowded in the ascus.

***rubi*, (*Valsa*)** Peck, Ann. Rep. New York State Mus. 28: 72, 73. (for 1874) 1876.

Type specimen (holotype): on stalks of *Rubus villosus*, Forestburgh, Sullivan Co., New York, Sept 1873, C. H. Peck.

Saccardo (1882) included Peck's name in the synonymy of *Valsa rubi* Fuckel, Symb. Mycol. p. 200. 1870. Peck's name is a later homonym of Fuckel's. Both belong in the synonymy of **Valsa ceratosperma** (Tode: Fr.) Maire.

***rubina*, (*Sphaerella*)** Peck, Ann. Rep. New York State Mus. 48: 114 (reprint p. 16). (for 1894) 1897.

Mycosphaerella rubina (Peck) House, Bull. New York State Mus. 233-234: 30. 1921.

Type specimen (holotype): on stalks of cultivated *Rubus* (raspberry), Menands, Albany Co., New York, April, C. H. Peck (a large collection now in a packet and a box; portion sent to NY in 1935 and is at NY).

This is **Didymella applanata** (Niessl) Sacc., as Corbaz (1957) recognized.

***saccharoides*, (*Sphaerella*)** Peck, Bull. New York State Mus. 167: 48. 1913.

Type specimen (holotype): on leaves of sugar cane, *Saccharum officinarum*, Cuba, 1912, T. E. Thurston, communicated by L. R. Hesler from Cornell University.

The fungus is pleosporaceous in structure and the ascospores are 3-5 septate. It is evidently a species of *Phaeosphaeria*, and pycnidia in the spots contain small, 5.5-6.5 × 2.5-3.5 μm, 0-1-septate hyaline conidia. According to the description of *Leptosphaeria saccharicola* P. Henn., Hedwigia 39(Beibl.): 79. 1900, the two could be identical. Transfer to *Phaeosphaeria* is not proposed at this time, since Hennings' specimen was not obtained for comparison.

***salebrosa*, (*Sphaeria*)** (*Denudatae*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 61. (for 1875) 1878.

Amphisphaeria salebrosa (Cooke & Peck) Sacc., Syll. Fung. 1: 726. 1882.

Trematosphaeria salebrosa (Cooke & Peck) Sivanesan, Trans. Brit. Mycol. Soc. 65: 397. 1975.

Byssosphaeria salebrosa (Cooke & Peck) Barr, Mycotaxon 20: 33. 1984.

Type specimen (isotype): on branches of *Vaccinium*, Center (= Karner), Albany Co., New York, Oct, C. H. Peck (portion sent to Cooke 5 March 1872 as #250).

This fungus is another of the species previously grouped in *Herpotrichia* (see Barr, 1984). Ascospores are similar to those of *Byssosphaeria schiedermayeriana* (Fuckel) Barr, but the lack of subiculum and yellowish rather than red pore area mark *B. salebrosa* as separate. It appears to be a species of northeastern North America, whereas *B. schiedermayeriana* is chiefly tropical in distribution. Figs. 37-38.

***sambucina*, (*Sphaerulina*)** Peck, Ann. Rep. New York State Mus. 38: 106. (for 1884) 1885.

Type specimen (holotype): on branches of *Sambucus canadensis*, West Albany, Albany Co., New York, May 1884, C. H. Peck.

This is **Dothiora sambucina** (Peck) Barr, Contr. Univ. Michigan Herb. 9: 574. 1972.

***sambucina*, (*Valsa*)** Peck, Ann. Rep. New York State Mus. 28: 75. (for 1874) 1876.

Pseudovalsa sambucina (Peck) Sacc., Syll. Fung. 2: 137. 1883.

Aglaospora sambucina (Peck) O. Kuntze, Rev. Gen. Pl. 3:441. 1898.

Thyridaria sambucina (Peck) Wehm., Lloydia 4: 253. 1941.

Type specimen (holotype): on stems and branches of elder (*Sambucus canadensis*), Hunter, Greene Co., (Catskill Mts.) New York, June 1874. Portion sent to Ellis by Peck (isotype, NY).

Thyridaria Sacc. was created to accommodate species whose grouped ascomata were surrounded by stromatic tissues. The grouped ascomata of *T. sambucina*, surrounded by yellowish to reddish-brown hyphae as a stromatic complex, are similar to those of *T. incrustans* Sacc., the type species of the genus. Ascospores of *T. sambucina* are smaller (13-15 × 4.5-5 μm) than those of *T. incrustans* (18-22 × 6-7.5 μm), but agree well in shape, septation and pigmentation. Fig. 126.

***scapophila*, (*Sphaeria*)** (*Caulicolae*) Peck, Ann. Rep. New York State Mus. 30: 66, 67. Pl. 2, Figs. 24-27. (for 1876) 1878.

Leptosphaeria scapophila (Peck) Sacc., Syll. Fung. 2: 43. 1883.

Type specimen (holotype): on scapes of *Sarracenia purpurea*, Lake Sallie (Lake Sally, near old village of Adirondack), Adirondack Mts., Essex Co., New York, Aug 1876, C. H. Peck.

The small ascomata and light yellowish ascospores strongly suggest **Phaeosphaeria fuckelii** (Niessl) Holm. The ascospores have 5 or 7 septa in this collection.

***scopula*, (*Sphaeria*)** (*Villosae*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 32: 51. (for 1878) 1880.

Lasiosphaeria (*Echinosphaeria*) *scopula* (Cooke & Peck) Cooke, Grevillea 15: 82. March 1887.

Acanthostigma scopula (Cooke & Peck) Peck, Bull. New York State Mus. 1(2): 22. Sept. 1887.

Tubeufia scopula (Cooke & Peck) Barr, Mycotaxon 12: 164. 1980.

Type specimen (isotype): on hemlock wood, Adirondack Mts., New York, Aug 1878, C. H. Peck.

A second collection in NYS, labelled *Acanthostigma clintonii* (Peck) Sacc., on *Acer* wood, Knowersville, Albany Co., New York, July, C. H. Peck is identical with *A. scopula*. Both are species of *Tubeufia* (Barr, 1980) and are recognized as setose species of section *Acanthostigmina*. Ascospore dimensions and septation separate *T. scopula* from *T. clintonii*.

***scrophulariae*, (*Lophiostoma*)** Peck, Ann. Rep. New York State Mus. 28: 76. (for 1874) 1876.

Lophiotrema scrophulariae (Peck) Sacc., Syll. Fung. 2: 683. 1883.

Type specimen (holotype): on stalks of *Scrophularia nodosa*, Green Island, Albany Co., New York, Oct 1874, C. H. Peck.

Ellis and Everhart (1892) considered Peck's species to be *Lophiotrema praemorsum* (Lasch) Sacc., and Berlese (1890) questionably did so, although he had not seen Peck's collection. The type specimen agrees with Berlese's illustrations of *L. praemorsum*. According to Chesters and Bell (1970) the earlier name for this entity is **Lophiostoma angustilabrum** (Berk. & Br.) Cooke.

***semen*, (*Sphaeria*)** (*Caulicolae*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 26: 87. (for 1872) 1874 (*nomen nudum*); 29: 65. (for 1875) 1878.

Metasphaeria semen (Cooke & Peck) Sacc., Syll. Fung. 2:170.
1883.

Byssosphaeria semen (Cooke & Peck) Barr, Mycotaxon 20: 36. 1984.

Type specimen (isotype): on fallen petioles and small twigs of *Sorbus* (*Pyrus*) *americana*, Sandlake, Rensselaer Co., New York, Sept 1871, C. H. Peck (portion sent to Cooke 30 Oct 1871 as #131).

This species is another of *Herpotrichia*-like taxa, now considered to be **Byssosphaeria semen**. It is related to *B. salebrosa* by the roughened surface of ascomata that are not appendaged or subiculate. Asci and ascospores are smaller in *B. semen*. Figs. 39-41.

***septorioides*, (*Sphaerella*)** Peck, Ann. Rep. New York State Mus. 32: 52. (for 1878) 1880.

Type specimen (holotype): on spotted leaves of *Thalictrum dioicum*, Central Bridge, Schoharie Co., New York, June 1878, C. H. Peck.

Peck's name, which is a later homonym of *Sphaerella septorioides* Desm. 1846, is synonymized under **Mycosphaerella thalictri** (Ellis & Everh.) Lindau in Engler & Prantl, Nat. Pflanzenfam. 1*: 424. 1897.

***seriata*, (*Cucurbitaria*)** Peck, Ann. Rep. New York State Mus. 28: 75. (for 1874) 1876.

Otthia seriata (Peck) Sacc., Syll. Fung. 1: 739. 1882.

Otthiella seriata (Peck) Sacc. & D. Sacc., Syll. Fung. 17: 662. 1905.

Type specimen (holotype): on branches of *Euonymus*, Albany, Albany Co., New York, Oct 1874, C. Devol.

This species is synonymous with **Nectria atrofusca** (Schw.) Ellis & Everh. (Barr in Bigelow and Barr, 1963).

***shepherdiae*, (*Pleospora*)** Peck, Ann. Rep. New York State Mus. 40: 71. (for 1886) 1887.

Type specimen (holotype): on branches of *Shepherdia canadensis*, Port Henry, Essex Co., New York, June 1886, C. H. Peck.

Wehmeyer (1961) accepted this species in the genus *Pleospora* and designated it the type of subgenus *Teichosporoides* Wehm. In Barr's opinion, Peck's fungus is a species of *Karstenula*, related to the type species, *K. rhodostoma* (Alb. & Schw.: Fr.) Speg. *Karstenula shepherdiae* has brown apical papilla and investing hyphae rather than the reddish papilla and investing hyphae of *K. rhodostoma*.

Karstenula shepherdiae (Peck) Barr, comb. nov. Figs. 52, 53.

Ascomata immersed, separate, surrounded and connected by brown hyphal tomentum, ascocarps depressed globose, 440-500 μm diam, 385 μm high, with a distinct apical papilla ca. 165 μm diam and high; wall ca 30 μm wide, 4-5 layers of slightly compressed cells. Asci from base and lower sides of locule, 100-130 × 10-12 μm, cylindric, bitunicate, short stipitate, (4-5-)8-spored; pseudoparaphyses trabeculate, anastomosing above asci and in pore area. Ascospores 16-22 × 7-8 μm, reddish brown, ellipsoid or occasionally fusoid, symmetric basically in shape and septation, (1-)3(-5)-septate, constricted at primary septum, one longitudinal septum through median cells, rarely through one end cell, each cell containing an angular globule, wall thick, smooth or with scattered roughenings, surrounded by narrow gel coat, uniseriate in the ascus.

Webster and Lucas (1961) described a *Coniothyrium* conidial state for this species from British specimens.

sieversiae, (***Lophiostoma***) Peck, Bull. New York State Mus. 167: 44. 1913.

Wettsteinina sieversiae (Peck) Barr, Canad. J. Bot. 45: 1042. 1967.

Type specimen (holotype): on stalks of *Sieversia turbinata* (*Geum rossii*) Big Cottonwood Canyon, Salt Lake Co., Utah, 3 July 1913, A. O. Garrett #702.

smilacinina, (*Sphaeria*) (*Caulicolae*) Peck, Ann. Rep. New York State Mus. 29: 62. (for 1875) 1878.

Anthostomella smilacinina (Peck) Sacc., Syll. Fung. 1: 281. 1882.

Botryosphaeria smilacinina (Peck) Barr, Contr. Univ. Michigan Herb. 9: 560. 1972.

Type specimen (holotype): on leaves of *Smilacina stellata*, Center (= Karner), Albany Co., New York, May 1875, C. H. Peck.

Laestadia smilacinae Dearness & House, Bull. New York State Mus. 205-206: 53. 1918 [*Guignardia smilacinae* (Dearness & House) Dearness & House, Bull. New York State Mus. 266: 73. 1925], was described from a collection of Peck's from Center, Albany Co., New York, and is identical with Peck's species.

sorghophila, (*Sphaeria*) (*Caulicolae*) Peck, Ann. Rep. New York State Mus. 31: 51. (for 1877) 1879.

Leptosphaeria sorghophila (Peck) Sacc., Syll. Fung. 2: 60. 1883.

Heptameria sorghophila (Peck) Cooke, Grevillea 18: 31. 1889.

Type specimen (holotype): on brush of an old broom, North Greenbush, Rensselaer Co., New York, June 1877, C. H. Peck.

The ascomata in this fungus have a rounded apex and a very short papillate pore. They seem intermediate between nonostiolate *Preussia* and definitely papillate *Sporormiella*. However, ascus shape is that of *Sporormiella* and the asci are in a hymenium, so the species is transferred to that genus. Berlese (1892) remarked that Peck's species was a synonym of *Sporormia leptosphaerioides* Speg., but that fungus has smaller ascospores and longer asci than does *S. sorghophila*.

Sporormiella sorghophila (Peck) Barr, comb. nov. Figs. 54, 55.

Ascomata immersed erumpent, often in rows, irregular in shape, elliptic or conic applanate, 165-180 μm diam, 210-220 μm high, apex rounded, apical pore area stuffed with small thin-walled cells; wall thin, 5-10(-15) μm wide, 2-3 layers of cells, thickest at lower sides, 5-6 layers of cells, cells dark brown and encrusted externally, hyaline and thick-walled internally. Asci 65-90 × 10-12 μm, bitunicate, clavate, short to long stipitate; pseudoparaphyses trabeculate, anastomosing. Ascospores 25-30 × 5-6 μm, dark brown, narrowly ellipsoid, ends tapered and rounded, straight or curved, 3-septate, deeply constricted, cells separating readily, end cells slightly longer than mid cells, one globule in each cell, wall smooth, longitudinal germ slit ± parallel to walls, suggestion of remnants of gel coat, overlapping biseriate or partially uniseriate in the ascus.

sparsa, (***Diaporthe***) Peck, Ann. Rep. New York State Mus. 39: 52. (for 1885) 1887.

Type specimen (holotype): on branches of *Rhus toxicodendron*, Saugerties, Ulster Co., New York, May 1885, C. H. Peck.

The name is a later homonym of *Diaporthe sparsa* Niessl 1883 and was changed to **Diaporthe peckii** Sacc., Syll. Fung. 9: 713. 1891. Wehmeyer (1933) accepted it as a valid species.

sparsum, (***Rhytisma***) Peck & Clinton, Bot. Gaz. 4: 171. 1879.

Cocconia sparsa (Peck & Clinton) Sacc., Syll. Fung. 8: 738. 1889. (as "P. & C.").

Type specimen (holotype): on *Sabal palmetto*, Florida, Jan 8, 1878, G. W. Clinton (a duplicate was sent to Durand and it is presumably at CUP-D).

The fungus is a species of **Hysterostomella, H. sparsa** (Peck & Clinton) Barr, comb. nov. (Figs. 8-10). *Hysterostomella sabalicola* Tracy & Earle, Bull. Torrey Bot. Club 28: 185. 1901, is synonymous with Peck and Clinton's species. It was described in detail under the latter name by Petrak and Ciferri (1930), who noted that Theissen and Sydow suggested the identity of the two.

sphaerellula, (***Sphaeria***) (*Obtectae*) Peck, Ann. Rep. New York State Mus. 30: 66. (for 1876) 1878.
Didymella sphaerellula (Peck) Sacc., Syll. Fung. 1: 547. 1882.
Cercidospora sphaerellula (Peck) O. Kuntze, Rev. Gen. Pl. 3: 454. 1898.
Mycosphaerella sphaerellula (Peck) Barr, Contr. Univ. Michigan Herb. 9: 604. 1972.
Type specimen (holotype): on twigs of *Acer pensylvanicum*, Phoenicia, Ulster Co., Catskill Mts., New York, June 1874, C. H. Peck.

sphaerophila, (***Periconia***) Peck, Ann. Rep. New York State Mus. 34: 50. Pl. 2, Figs. 17-20. (for 1880) 1882.
Sporocybe sphaerophila (Peck) Sacc., Syll. Fung. 4: 609. 1886.
Melanospora sphaerophila (Peck) Sacc. ex Thaxter & Linder, Reliquiae Farlowianae 56. 1922.
Phaeostoma sphaerophila (Peck) Barr in Bigelow & Barr, Rhodora 64: 134. 1962.
Scopinella sphaerophila (Peck) Malloch, Fungi Canad. No. 83. 1976.
Type specimen (holotype): on ascomata of *Apiosporina* (*Sphaeria*) *morbosa* on *Prunus* branches, Edmond's Pond, Adirondack Mts., Essex Co., New York, July 1880. C. H. Peck.

spiraeae, (**Lophiostoma**) Peck, Ann. Rep. New York State Mus. 28: 76. (for 1874) 1876.
Lophiotrema spiraeae (Peck) Sacc., Syll. Fung. 2: 686. 1883.
Lophiotrema praemorsum (Lasch) Sacc. f. *spiraeae* (Peck) Rehm, Ann. Mycol. 9: 99. 1911.
Type specimen (holotype): on *Spiraea* (*Opulaster*) *opulifolius*, Rhinebeck, Dutchess Co., New York, June 1874, C. H. Peck (now in two packets plus a duplicate sent to New York in 1935 and is at NY).

Chesters and Bell (1970) examined Peck's type specimen and included it under *Lophiostoma alpigenum* Fuckel. Barr disagrees and retains **Lophiostoma spiraeae** as a separate species on the basis of short broad asci and narrow ascospores that are not constricted at the 5-11 septa.

spiraeae var. ***adultum***, (***Lophiostoma***) Peck, Ann. Rep. New York State Mus. 38: 111. (for 1884) 1885.
Type specimen (holotype): on *Spiraea opulifolia*, West Albany, Albany Co., New York , April 1884, C. H. Peck.

This variety is macroscopically and microscopically similar to var. *spiraeae*, and like it, is **Lophiostoma spiraeae**.

spleniata, (***Sphaerella***) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 25: 105. (for 1871) 1873.
Mycosphaerella spleniata (Cooke & Peck) House, Bull. New York State Mus. 233-234: 30. 1921.
Type specimen (isotype): on leaves of *Quercus bicolor*, North Greenbush, Rensselaer Co., New York, June 1871, C. H. Peck (portion sent to Cooke 5 June 1871 as #29).

Peck indicated (Ann. Rep. New York State Mus. 33: 38.1883) that *Sphaerella nigrita* Cooke was not specifically distinct from his species, but then hedged in his notes by treating *S. nigrita* as a variety of *S. spleniata*. This combination does not appear to be published. A portion of the type of *S. nigrita* Cooke is at NYS (isotype): on leaves of *Quercus*, Poughkeepsie, W. R. Gerard.

squalidula, (***Sphaeria***) (*Denudatae*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 61. (for 1875) 1878.
Wallrothiella squalidula (Cooke & Peck) Sacc., Syll. Fung. 1: 456. 1882.
Type specimen (isotype): on decorticated chestnut wood, Portville, Cattaraugus Co., New York, Sept 1871, C. H. Peck (a portion was sent to Cooke 1 Nov 1871 as #135).

The type collection is sparse and the few, brittle, gregarious perithecia are overmature. No asci were recognizable; the few ascospores seen were 13-14.5 × 3.5-5 μm, brown, oblong, 3-septate. The original description of this fungus is:

Perithecia gregarious, globose, semi-immersed, pierced at the apex, about .012' broad, black; asci cylindrical; spores uniseriate, elliptical, simple, binucleate, colorless, .0005'-.0007' long."

staphylina, (***Sphaeria***) Peck, Bull. Buffalo Soc. Nat. Sci. 1: 72. 1873; Ann. Rep. New York State Mus. 26: 86, 87. (for 1872) 1874.
Metasphaeria staphylina (Peck) Sacc., Syll. Fung. 2: 167. 1883.
Hysterium staphylina (Peck) Dearness & House, Bull. New York State Mus. 188: 34. 1916.
Dothiora staphylina (Peck) Barr, Contr. Univ. Michigan Herb. 9: 574. 1972.
Type specimen (holotype): on branches of *Staphylea trifoliata*, Helderberg Mts., New York, May 1872; C. H. Peck. Fig. 127.

subclypeata, (*Valsa*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 27: 109. (for 1873) 1875.

Engizostoma subclypeatum (Cooke & Peck) O. Kuntze, Rev. Gen. Pl. 3: 475. 1898.

Type specimen (lectotype): on branches of *Quercus,* Forestburgh, Sullivan Co., New York, Sept 1873, C. H. Peck. Syntype collections: on branches of *Rhododendron maximum* and branches of *Sassafras officinale,* Forestburgh, New York, Sept 1873, C. H. Peck (portion sent to Cooke on 5 March 1874 as #341 *Valsa cincta*; duplicate sent to Ellis 1 Nov 1876 and is at NY).

The original description gave the type as on "Dead branches of oak and *Rhododendron.* Forestburgh. Sept." Both hosts are included in the type packet; in a second packet are a twig of *Sassafras,* and another of *Quercus.* On all of these the fungus is identical, but varies in maturity of asci and ascospores. The stromata are pseudoparenchymatous, surrounded by a dark conceptacle, and the perithecial ostioles emerge through a minute white disc. Asci and ascospores are small, the latter 7-10 × 1.5-2 µm. This is a species of *Leucostoma,* closely related to **Leucostoma auerswaldii** (Nits.) v. Höhnel. Because the microscopic details within species of *Leucostoma* vary to a certain extent, and host range also varies, this is considered only as a small form of *L. auerswaldii,* rather than a separate species.

subconfluens, (*Aulographum*) Peck, Ann. Rep. New York State Mus. 28: 70. (for 1874) 1876. As "*Ailographum*".

Type specimen (holotype): on herbaceous stems, Umbelliferae (*Thalictrum* fide H. D. House), North Greenbush, Rensselaer Co., New York, June 1874, C. H. Peck.

This fungus conforms well with others in *Leptopeltis* and is most closely related to *L. lunariae* (Fuckel) Holm & Holm (1977); they are separated by sizes and substrates.

Leptopeltis subconfluens (Peck) Barr, comb. nov. Figs. 5-7.

Perithecia superficial, flattened, black, rounded, elliptic or irregular, or two or more confluent and elongate, 190-220 (-1000) × 275-385 µm, 65-90 µm high at thickest mid portion, tapered to margins, opening by irregular longitudinal slit; wall narrow, radiating from surface, dark reddish brown, base hyaline, no superficial hyphae seen. Asci upright from base, 25-30 × 6-8 µm, oblong, unitunicate, in elongate paraphyses which are light brownish and granular beneath apical slit. Ascospores 7-19 × 3-4 µm, hyaline, narrowly obovoid, 1-celled or delicately 1-septate, submedian, contents granular, wall smooth, overlapping biseriate in the ascus.

subconica, (*Sphaeria*) (*Caulicolae*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 26: 87. (for 1872) 1874 (*nomen nudum*); 29: 65. (for 1875) 1878.

Leptosphaeria subconica (Cooke & Peck) Sacc., Syll. Fung. 2: 15. 1883.

Type specimen (isotype): on dead herbs, Moose River near Greig, Lewis Co., New York, Sept 1870, C. H. Peck (now in two packets; portion sent to Cooke 5 July 1871 as #64).

Peck's notes in one of the type packets gives the host as *Mulgedium* (= *Lactuca*), although Homer House later annotated one packet as being on *Solidago* and the other *Oenothera.* Holm (1957) studied the holotype at K and recognized that the fungus was identical with **Leptosphaeria doliolum** (Pers.: Fr.) Ces. & de Not.

subcorticalis, (*Sphaeria*) Peck, Ann. Rep. New York State. Mus. 28: 77, 78. (for 1874) 1876.

Trichosphaeria subcorticalis (Peck) Sacc., Syll. Fung. 1: 454. 1882.

Enchnoa subcorticalis (Peck) Barr in Bigelow & Barr, Rhodora 71: 198. 1969.

Type specimen (holotype): on branches of *Carpinus caroliniana,* North Greenbush, Rensselaer Co., New York, June 1874, C. H. Peck (now in two packets).

subdenudata, (*Sphaeria*) (*Ceratostomae*) Peck, Ann. Rep. New York State Mus. 32: 52. (for 1878) 1880.

Ceratostoma subdenudata Peck in Sacc., Syll. Fung. 9: 481. 1891.

Type specimen (holotype): on decaying wood, Griffins, Catskill Mts., Delaware Co., New York, Sept 1877, C. H. Peck (duplicate sent to BPI in 1945).

This is a species of *Ceratostomella* with sulcate tips to the ostioles.

Ceratostomella subdenudata (Peck) Barr, comb. nov. Figs. 91-93.

Perithecia scattered or closely grouped, immersed or nearly superficial with only bases immersed, varying in position from upright to nearly horizontal, dull black, appressed hyphae covering exposed surfaces, 385-495 µm diam, with broad central or lateral ostioles, 275-500 µm long, 150-180 µm diam near base, tapering slightly to 3-4-sulcate apex, canal periphysate; perithecial wall thick, up to 40 µm wide, of numerous layers of compressed cells. Asci 50-90 × 7.5-10 µm, elliptic oblong, unitunicate, floating free and numerous in centrum, apical annulus refractive in water, chitinoid, nonamyloid; few broad deliquescent paraphyses present (in fresh material). Ascospores 11-14.5 × 3.5-5 µm, hyaline becoming light dull brown, ellipsoid, often inequilateral or slightly curved, 1-celled, becoming 1-5-

pseudoseptate, not constricted, contents guttulate or one large globule, wall thin, smooth, overlapping uniseriate to biseriate in the ascus.

Additional collections: Indian Lake, Hamilton Co., New York, Oct 1878, C. H. Peck (NYS); Mt. Toby, Franklin Co., Massachusetts, 6 Oct 1967, Barr #5086, same locality, 9 July, 1968, Barr #5168 (MASS).

***subolivaceus*, (*Ophiobolus*)** Peck, Ann. Rep. New York State Mus. 46: 116 (reprint p. 36). (for 1892) 1893.

Type specimen (holotype): on stalks of a *Thalictrum* (apparently *Thalictrum polygamum*), Mechanicville, Saratoga Co., New York, May 1892, C. H. Peck.

The specimen has 5-septate ascospores, constricted at the primary median septum, 30-35 × 3.5-4 μm. Its characteristics are in agreement with those given by Holm (1957) for **Leptosphaeria ogilviensis** (Berk. & Br.) Ces. & de Not.

***suborbiculare*, (*Hypoxylon*)** Peck, Ann. Rep. New York State Mus. 30: 63, 64. (for 1876) 1878.

Type specimen (holotype): on bark of *Fraxinus nigra*, Sandlake, Rensselaer Co., New York, Sept 1876, C. H. Peck.

This taxon has been involved in considerable confusion.It was originally described as "*Diatrype cercidicola* Berk. & Curt.," on a collection or G. W. Clinton, by Peck who likened it to a specimen sent by Curtis bearing that unpublished name. Peck later made the Sandlake collection of the same species and described it as *H. suborbiculare*, but in doing so he created a later homonym of *H. suborbiculare* Welw. & Curr. 1867. Some time after publication Peck corrected the substrate identification from *Acer saccharinum* to *Fraxinus nigra*.

Miller (1961) relegated the name to the synonymy of **Hypoxylon rubiginosum** (Pers.: Fr.).

substerilis (Leptosphaeria) Peck, Bull. New York State Mus. 105: 24, 25. 1906.

Type specimen (holotype): on living leaves of *Mentha piperata*, Lakeport, Madison Co., New York, July 14, 1905, C. H. Peck.

The fungus is a small species of *Leptosphaeria*, belonging in Holm's (1957) "groupe *Johansonii*." In addition to the ascomata in leaf spots, there are small *Phyllosticta*-like pycnidia present. The conidia are 4.5-6 × 1-1.5 μm, hyaline, one-celled.

suffusa Tul. var. ***nuda*, (*Cryptospora*)** Peck, Ann. Rep. New York State Mus. 46: 138 (reprint p. 58). (for 1892) 1893.

Type specimen (lectotype): on branches of *Corylus*, Center (= Karner), Albany Co., New York, May 1892, C. H. Peck; (syntypes): Karner, Sept 1892, C. H. Peck; West Albany, May, *Alnus incana* C. H. Peck. Peck's notebooks give Karner, May & Sept, *Alnus* & *Corylus* for the host of the variety.

J. Reid has studied the lectotype specimen and annotated it as *Cryptospora corylina* (Tul.) Fuckel. This is **Ophiovalsa corylina** (Tul.) Petrak.

***superficialis*, (*Melogramma*)** Peck & Clinton in Peck, Ann. Rep. New York State Mus. 29: 57, 58. (for 1875) 1878.

Fenestella superficialis (Peck & Clinton) Sacc., Syll. Fung. 2: 231. 1883.

Type specimen (holotype): on bark of living *Sorbus* (*Pyrus*) *americana*. Buffalo, Erie Co., New York, May 1875, G. W. Clinton.

This fungus is a species of *Myriangium*, identical with *M. asterinosporum* (Ellis & Everh.) Miller. Ellis N. A. F. #1279 of *Cenangium asterinosporum* Ellis & Everh. is authentic material of the species, and Miller's (1940) description of the species agrees entirely with Peck and Clinton's species. The latter is the earlier epithet, so that the combination **Myriangium superficialis** (Peck & Clinton) Barr, comb. nov., is proposed. Fig. 1.

***superficialis*, (*Torrubia*)** Peck, Ann. Rep. New York State Mus. 28: 70. (for 1874) 1876.

Cordyceps superficialis (Peck) Sacc., Syll. Fung. 2: 574. 1883.

Type specimen (holotype): on buried larvae under hemlocks, Northville, Fulton Co., New York, Aug., C. H. Peck.

Mains (1958) accepted **Cordyceps superficialis** as a valid species.

***taxicola*, (*Sphaeria*)** Peck, Ann. Rep. New York State Mus. 24: 99. (for 1870) 1872.

Leptosphaeria taxicola (Peck) Sacc., Syll. Fung. 2: 85. 1883.

Metasphaeria taxicola (Peck) Peck, Ann. Rep. New York State Mus. 39: 58. (for 1885) "1886" .

Sphaerulina taxicola (Peck) Berlese, Icon. Fung. 1: 125. 1894.

Saccothecium taxicolum (Peck) Kirschstein, Kryptogamenfl. Mark Brandenburg 7(3): 427. 1938.

Dothiora taxicola (Peck) Barr, Contr. Univ. Michigan Herb. 9: 575. 1972.

Type specimen (holotype): on leaves of *Taxus canadensis*, Sandlake, Rensselaer Co., New York, May 1870, C. H. Peck. Fig. 128.

thujae, (Valsa) Peck, Ann. Rep. New York State Mus. 40: 67. (for 1886) 1887.

Type specimen (holotype): on *Thuja occidentalis*, Elizabethtown, Essex Co., New York, Sept 1886, C. H. Peck (now in two packets).

This appears to be a valid species of *Valsa*, with whitish to dull yellowish brown stromatic disc and ascospores 9-13 × 2-2.5 μm. Fig. 129.

***thujarum*, (*Hysterium*)** Cooke & Peck in Cooke, (as *thuiarum*) Bull. Buffalo Soc. Nat. Sci. 3: 33. 1875.

Mytilinidion thujarum (Cooke & Peck) Lohman, Pap. Michigan Acad. Sci. 17: 258. 1932 . (as *Mytilidion*).

Type specimen (isotype): on *Thuja occidentalis*, New Baltimore, Greene Co., New York, June 1871, E. C. Howe (portion sent to Cooke 27 June 1871 as #46; duplicates also sent to W. R. Gerard 17 Feb 1875 and to New York 1935 and is at NY).

The type packet states "Leg. C. H. Peck." This is probably in error since Howe's address in 1871 was New Baltimore.

***thujina*, (*Sphaeria*)** Peck, Ann. Rep. New York State Mus. 27: 110. (for 1873) 1875.

Amphisphaeria thujina (Peck) Sacc., Syll. Fung. 1: 726. 1882.

Kirschsteiniella thujina (Peck) Pomerleau & Etheridge, Mycologia 53: 160. 1961 .

Kirschsteiniothelia thujina (Peck) Hawksworth, Bot. J. Linn. Soc. 89: 198. 1985.

Type specimen (holotype): on wood of *Thuja occidentalis*, Adirondack Mts., New York, 1873, C. H. Peck. Additional collections in NYS: on *Thuja occidentalis*, Mt. Washington, N. H., C. G. Pringle, #329; Charlotte, Vt., C. G. Pringle, #488; on dead fir, Newfoundland, 24 June 1893, Waghorne.

Pomerleau and Etheridge (1962) redescribed this species and discussed the blue stain which it causes in some detail. See comments under *S. phileura*.

***tomentella*, (*Valsa*)** (*Cryptospora*) Peck, Ann. Rep. New York State Mus. 35: 144. (for 1881) 1884.

Cryptospora tomentella (Peck) Berl. & Vogl., Syll. Fung. Addit. 1-4: 192. 1886.

Ophiovalsa tomentella (Peck) Petrak, Sydowia 19: 275. 1966.

Type specimen (holotype): on *Betula populifolia*, West Albany, Albany Co., New York, May 1881, C. H. Peck (now in two packets).

***tracyi*, (*Asterula*)** Peck, Ann. Rep. New York State Mus. 47: 152. (for 1893) 1894.

Type specimen (holotype): on hyphae and conidiophores of *Cercospora borreriae* Ellis & Everh. on living leaves of *Spermococe parviflora (Borreria micrantha)*, Biloxi, Mississippi, 25 July 1892, S. M. Tracy #1842. Duplicate at NY from Tracy herbarium via Earle.

The minute fungus is a species of *Trichothyrina*, smaller than most of the described species.

Trichothyrina tracyi (Peck) Barr, comb. nov. Figs. 13-15.

Ascomata thickly scattered on the *Cercospora* hyphae, shining black, lens-shaped, (40-)52-78 μm diam, 32-40 μm high, with abrupt papillate apex; wall apparently one layer thick, both upper and lower surfaces of nearly cubical cells in radiating rows. Asci 20-25 × 11-14 μm, bitunicate, saccate oblong, sessile, no pseudoparaphyses seen, apical periphysoids present. Ascospores 9-10 × 2-2.5 μm, hyaline, narrowly obovoid, 1-septate, not constricted, usually two globules per cell, wall smooth, crowded in the ascus.

***transformans*, (*Hypomyces*)** Peck, Ann. Rep. New York State Mus. 29: 57. (for 1875) 1878.

Peckiella transformans (Peck) Sacc., Syll. Fung. 9: 945. 1891.

Type specimen (holotype): on *Cantharellus cibarius*, Sandlake, Rensselaer Co., New York, Aug 1875, C. H. Peck (now in two boxes).

Hypomyces transformans is a distinct species.

***trichispora*, (*Valsa*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 58. (for 1875) 1878.

Cryptospora trichispora (Cooke & Peck) Sacc., Syll. Fung. 2: 363. 1883.

Type specimen (isotype): on branches of *Quercus*, Greenbush, Rensselaer Co., New York, Nov, C. H. Peck (sent to Cooke prior to 6 May 1871 as #7).

The fungus has narrow ascospores, 36-44(-53) × 1.5-2(-2.5) μm, which become 1-3(-7)-septate. It is **Ophiovalsa trichispora** (Cooke & Peck) Barr, Mycol. Mem. 7: 145. 1978. Figs. 87-89.

***triseptata*, (*Lophiostoma*)** Peck, Ann. Rep. New York State Mus. 28: 76. (for 1874) 1876.

Lophiostoma quadrinucleatum Karst. var. *triseptatum* (Peck) Chesters & Bell, Mycol. Pap. 120: 36. 1970.

Type specimen (lectotype): on decaying wood of ?*Pyrus*, Sterling, Cayuga Co., New York, Aug 1874, C. H. Peck; (syntype): on decaying wood of *Fraxinus*, Buffalo, Erie Co., New York, Aug 1874, G. W. Clinton.

Both collections bear the identical fungus. The Peck collection from Sterling is herewith designated lectotype since the label evidence indicates that it was studied in more detail by Peck.

Chesters & Bell (1970) discussed this and closely related names and grouped them under **Lophiostoma quadrinucleatum** var. **triseptatum**. Fig. 130.

Two unpublished varieties were designated in the herbarium by C. H. Peck:

Lophiostoma triseptata var. *minimum* Peck: on *Juglans cinerea*, Elizabethtown, Essex Co., New York, Sept, C. H. Peck.

Lophiostoma triseptata var. *nigrificans* Peck: on *Populus*, Delmar, Albany Co., New York, June, C. H. Peck.

Although the ascospores are small, 13-17 × 3.5-5 μm, these collections also can be accommodated in *Lophiostoma quadrinucleatum* Karst. var. *triseptatum*.

***truncata*, (*Valsa*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 25: 103. (for 1871) 1873.

Type specimen (isotype): on branches of *Alnus*, Johnsburgh, Warren Co., New York, Oct 1870, C. H. Peck (portion sent to Cooke 5 June 1871).

The fungus is **Valsa melanodiscus** Otth as Petrak (1940) has stated.

***truncatulum*, (*Hysterium*)** Cooke & Peck in Cooke, Bull. Buffalo Soc. Nat. Sci. 3: 33. 1875; Ann. Rep. New York State Mus. 30: 63. (for 1876) 1878.

Type specimen (isotype): on decaying wood, Buffalo, Erie Co., New York, G. W. Clinton (A collection was sent to Cooke 14 Nov 1871 as #165 along with a drawing of the spores. It bore the name *Hysterium teres* B & C with the species epithet crossed out and replaced with "*biforme*." The bottom of the sheet bears the epithet *Hysterium truncatulum* C & P. This specimen along with a detailed drawing of it by William Phillips is now at Kew. A duplicate was sent to Gerard 17 Feb 1875.)

The ascospores in the isotype specimen are (20-)25-30x 5-7 μm, 3-septate, with end cells pallid, mid cells brown. This is a form of **Hysterium pulicare** Pers.: Fr. as Ellis and Everhart (1892) and Bisby (1932) observed.

tuberculosa Sacc. var. ***dispersa*, (*Diaporthe*)** Peck, Ann. Rep. New York State Mus. 44: 140. (for 1890) 1891.

Type specimen (holotype): on branches of *Amelanchier canadensis*, Carrollton, Cattaraugus Co., New York, Sept 1890, C. H. Peck.

Wehmeyer (1933) included Peck's variety in **Diaporthe tuberculosa** (Ell.) Sacc. var. *tuberculosa*.

***tumidella*, (*Diatrype*)** Peck, Bull. New York State Mus. 167: 40, 41. 1913.

Type specimen (holotype): on branches of *Prunus pensylvanica*, Ste. Anne de Bellevue, Quebec, Canada, 17 Feb 1912. W. Fraser (now in two packets).

This is close to *Diatrype albopruinosa* (Schw.) Ellis & Everh. The ectostromatic coating over blackened entostroma is whitish in *D. albopruinosa*, cinereous or brown in *D. tumidella*. Asci in *D. tumidella* are considerably smaller (30-40 × 7-12 μm) than in *D. albopruinosa* (60-82 × 9-13 μm). Because ascus size appears to be a specific character in many of the Diatrypaceae, **Diatrype tumidella** Peck is retained as a valid species.

***tumidula*, (*Valsa*)** Cooke & Peck in Peck, Ann. Rep. New York State Mus. 29: 58. (for 1875) 1878.

Eutypella tumidula (Cooke & Peck) Sacc., Syll Fung. 1: 155. 1882.

Engizostoma tumidulum (Cooke & Peck) O. Kuntze, Rev. Gen. Pl. 3: 475. 1898.

Type specimen (isotype): on branches of *Crataegus*, Garrisons, Putnam Co., New York, June 1870, C. H. Peck (portion sent to Cooke 28 March 1872 as #266).

The species belongs with those whose asci are small [p. sp. 15-30(-35) μm long] and ascospores are in the size range of 5.5-11 μm long. **Eutypella tumidula** seems closely related to *E. prunastri* (Pers.: Fr.) Sacc.

turritum (Lophiostoma) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 26: 86. (for 1872) 1874 (*nomen nudum*); Grevillea 4: 180. 1876; Ann. Rep. New York State Mus. 29: 64. (for 1875) 1878.

Type specimen (isotype): on branches of *Salix*, Sandlake, Rensselaer Co., New York, Sept, C. H. Peck (now in two packets at NYS; portion sent to Cooke 1 Nov 1871 as #134).

A few of the ascospores have a longitudinal septum in one cell, but the majority are transversely septate only. The rich brown pigmentation and narrower ascospores separate this taxon from *Lophiostoma pseudomacrostomum* Sacc.

***typhae*, (*Didymosphaeria*)** Peck, Ann. Rep. New York State Mus. 38: 104. (for 1884) 1885.

Type specimen (holotype): on leaf bases of *Typha latifolia*, Guilderland, Albany Co., New York, May 1884, C. H. Peck (duplicate sent to NY 1935 and is at NY).

The fungus is identical with **Didymosphaeria futilis** (Berk. & Br.) Rehm. Holm (1957) described *D. futilis* in some detail and noted that numerous plants, both monocots and dicots, were hosts for the species.

underwoodii, (Diatrypella) Peck, Ann. Rep. New York State Mus. 46: 119 (reprint p. 39). (for 1892) 1893.

Type specimen (holotype): on branches of mesquite, *Prosopis glandulosa*, Austin, Texas, 24 Nov 1891, L. M. Underwood. Duplicate from Underwood at NY.

The coarsely lobed surfaces of small stromata distinguish this species from those others which have many small ascospores [4-8(-10) μm long] in the ascus.

***vaccinii*, (*Microsphaera*)** (Schw.) Cooke & Peck, J. Bot II. 10: 13. 1872; Ann. Rep. New York State Mus. 23: 65. (for 1869) 1872.

Erysiphe vaccinii Schw., Trans. Amer. Philos. Soc. II. 4: 270. 1832. (in part).

Peck had specimens from New York on *Vaccinium*, West Albany, Albany Co., on *Vaccinium pennsylvanicum*, Adirondack Mts., on *Vaccinium vacillans*, New Scotland, Albany Co., on *Gaylussacia baccata*, Eastport, Long Island, Suffolk Co., and on *Epigaea repens*, Wading River, Suffolk Co.

Salmon (1900) recognized *Microsphaera alni* Salm. var. *vaccinii* (Schw.) Salmon. This is *M. penicillata* (Wallr.: Fr.) Lév. var. *vaccinii* (Schw.) W. B. Cooke (1952), perhaps better as a separate species, **M. vaccinii** (Schw.) Cooke & Peck. Fig. 131.

***valsoides*, (*Sphaeria*)** Peck, Ann. Rep. New York State Mus. 28:78. (for 1874) 1876.

Sordaria valsoides (Peck) Sacc., Syll. Fung. 1: 235. 1882.

Pleurage valsoides (Peck) O. Kuntze, Rev. Gen. Pl. 3: 505. 1898.

Type specimen (holotype): on cow dung, Sageville, Hamilton Co., New York, Aug 1874, C. H. Peck (now in two packets).

The type collection belongs in the genus *Podospora* in the sense of Mirza and Cain (1969). These authors had not seen the material and noted only that it was probably *P. appendiculata* (Auersw.)Niessl. However, the presence of agglutinated appendages on the perithecia separates the specimen from that species, and it conforms rather with *Podospora aloides* (Fuckel) Mirza & Cain. N.Lundquist has annotated the type specimen as **Schizothecium aloides** (Fuckel). Lundq., Symb. Bot. Upsal. 20(1): 253. 1972.

***variabile*, (*Hysterium*)** Cooke & Peck in Cooke, Bull. Buffalo Soc. Nat. Sci. 3: 33. 1875.

Hysterographium variabile (Cooke & Peck) Sacc., Syll. Fung. 2: 780. 1883.

Type specimen (isotype): on chestnut posts, Greenbush, Rensselaer Co., New York, May, C. H. Peck. Portion sent to Cooke 22 May 1871 as #21. It was labeled "*Hysterium variabile* C & P" in Peck's hand and contains a small drawing of the spores (K). An additional portion of collection #21 is at (K) from the Phillips herbarium along with a detailed drawing by Phillips, and a portion was sent to Gerard 17 Feb 1875. Portion sent to Ellis is at NY. Additional collections: on *Castanea* wood, Knowersville, Albany Co., New York, May, C. H. Peck; on *Hicoria* wood (or ash), Guilderland, Albany Co., New York, May, C. H. Peck.

These specimens are **Hysterographium mori** (Schw.) Rehm, as Bisby (1932) observed.

variegata, (Leptosphaeria) Peck. Bull. New York State Mus. 67: 31, 32. (for 1902) 1903.

Type specimen (holotype): on stalks of *Phytolacca decandra*, Trenton Falls, Oneida-Herkimer Co. line, New York, Sept 1870, C. H. Peck.

This small-spored fungus (ascospores 11-18 × 4-5 µm, 3-septate) is a valid species of *Leptosphaeria*, belonging in Holm's (1957) "groupe *doliolum*." The ascomata in reddish areas of the stalk lack the concentric rings of thickening found in *L. doliolum* (Pers.: Fr.) Ces. & de Not. It was originally reported by Peck as *Sphaeria lilacina* Schw. Fig. 132.

***verrucoides*, (*Diatrype*)** Peck, Ann. Rep. New York State Mus. 32: 50. (for 1878) 1880.

Type specimen (holotype): on branches of *Fagus*, Stamford, Delaware Co., New York, Sept 1877, C. H. Peck.

The type specimen is immature; it is identical with **Diatrype albopruinosa** (Schw.) Cooke & Ellis.

***vestita*, (*Lophiotrema*)** Peck, Ann. Rep. New York State Mus. 40: 71. (for 1886) 1887.

Type specimen (holotype): on wood of *Populus tremuloides*, Gansevoort, Saratoga Co., New York, Sept 1886, C. H. Peck (now in two packets).

The type specimen does not have the apical papilla truly compressed, and the ascomata are clothed with orange, reddish, or brownish hyphae. It was described in the same report as *L. parasitica* and is also a synonym of **Pseudotrichia mutabilis** (Pers.: Fr.) Wehmeyer.

***viridella*, (*Sphaeria*)** (*Caulicolae*) Peck, Ann. Rep. New York State Mus. 30: 66. (for 1876) 1878.

Leptosphaeria viridella (Peck) Sacc., Syll. Fung. 2: 18. 1883.

Type specimen (holotype): on stalks of *Melilotus alba*, Bethlehem, Albany Co., New York, Sept 1876, C. H. Peck.

This species is close to *Leptosphaeria pratensis* Sacc. & Briard, but the ascospores are smaller (17-20 × 3-3.5 µm as compared to 20-23 × 5-6 µm for *L. pratensis*). The greenish tinge to the stalks is slight in dried material. **Leptosphaeria viridella** (Peck) Sacc. belongs in Holm's (1957) "groupe *Johansonii*" with *L. pratensis*.

***viridicoma*, (*Sphaeria*)** (*Villosae*) Cooke & Peck in Peck, Ann. Rep. New York State Mus. 26: 87. (for 1872) 1874 (*nomen nudum*); 29: 64. (for 1875) 1878.

Lasiosphaeria viridicoma (Cooke & Peck) Sacc., Syll. Fung. 2: 193. 1883.

Lophiotricha viridicoma (Cooke & Peck) Kauffman, Pap. Michigan Acad. Sci. 9: 189. 1929.
Pseudotrichia viridicoma (Cooke & Peck) Wehm., Canad. J. Res. C. 20: 579. 1942.
Type specimen (isotype): on dead branches of *Fagus*, Sandlake, Rensselaer Co., New York, Oct 1872, C. H. Peck.

The type and other specimens under the same name in NYS are **Pseudotrichia mutabilis** (Pers.: Fr.) Wehm.

***viridis*, (*Hypocrea*)** (Tode) Peck, Ann. Rep. New York State Mus. 31: 49. (for 1877) 1879.

Peck reported a collection on maple chips, Griffins, Delaware Co., New York, Sept 1877, C. H. Peck, as *Hypocrea viridis* Tode and noted, "This is so unlike our ordinary forms of *H. gelatinosa* that it seems best to keep them distinct, though some botanists unite them." On the label of his collection, but not in the Report or in his Notebook, Peck added the name "*Hypocrea gelatinosa* v. *viridis* Sacc." Saccardo (Syll. Fung. 2: 524. 1883) included *Hypocrea gelatinosa* (Tode: Fr.) Fr. var *viridis* (Tode) Sacc. citing "Tode f. 124" which refers to *Sphaeria gelatinosa viridis* Tode (Fungi Meckl. Sel. 2: 48. fig. 124. 1791). It appears that Peck's combination can be accepted as a clear and unambiguous elevation from varietal to specific rank. However, it is impossible to determine if Peck's material is the same as that of Tode since no specimens of Tode's have been located and his description could apply to several species of *Hypocrea*. Seaver (1910) attributed the name to Peck alone (*Hypocrea viridis* Peck) and indicated it to be a doubtful synonym of *Chromocrea gelatinosa* (Tode: Fr.) Seaver. Apparently Seaver did not study Peck's specimens. In Rogerson's opinion Peck's material represents a species distinct from *Hypocrea gelatinosa*, but further study is needed to determine the correct name for it.

***viticolum*, (*Hysterium*)** Cooke & Peck in Cooke, Bull. Buffalo Soc. Nat. Sci. 3: 33. 1875.
Hysterographium viticolum (Cooke & Peck) Sacc., Syll. Fung. 2: 782. 1883.
Type specimen (syntype): dead branches of grapevine, Poughkeepsie, New York, Gerard; (syntype): on wood of *Vitis*, Greenbush, Rensselaer Co., New York, C. H. Peck.

The protologue gives "New York (Peck 124)" as the only specimen information. Specimen #124 was first sent to Cooke 24 Oct 1871. This was a portion of the Gerard specimen which turned out to be sterile. The Greenbush specimen was sent at a later date also as #124. Both of these specimens plus several other Gerard specimens and a nice drawing by Phillips are in the type folder at Kew. The Peck herbarium contains the major portion of the Peck and Gerard specimens.

This is **Hysteriographium mori** (Schw.) Rehm, according to Bisby (1932) and to Zogg (1943, 1962).

***volemi*, (*Hypomyces*)** Peck, Bull. Torrey Bot. Club 27: 20. 1900.
Type specimen (holotype): parasitic on the hymenium of *Lactarius volemus*, Mt. Gretna, Colebrook, Lebanon Co., Pennsylvania, 31 Aug 1899, C. McIlvaine.

Hyopomyces volemi is a synonym of **H. lateritius** (Fr.) Tulasne, Ann. Sci. Nat. Bot. IV, 13: 11, 12. 1860.

***woolworthi*, (*Valsa*)** Peck, Ann. Rep. New York State Mus. 28: 73. (for 1874) 1876.
Diaporthe woolworthii (Peck) Sacc., Syll. Fung. 1: 615. 1882.
Type specimen (holotype): on branches of hickory, Greenbush, Rensselaer Co., New York, Sept 1874, C. H. Peck (a large collection now in two packets). The type was originally thought to be on *Quercus* and was given the herbarium name *Valsa quercina*.

According to Wehmeyer (1933) the fungus is a synonym of **Diaporthe eres** Nits.

***xanthoxyli*, (*Massariella*)** Peck, Ann. Rep. New York State Mus. 46: 116 (p. 36 of reprint). (for 1892) 1893.
Massaria xanthoxyli (Peck) Petrak, Ann. Mycol. 23: 138. 1925.
Type specimen (holotype): on branches of *Xanthoxylum americanum*, Mechanicville, Saratoga Co., New York, May 1892, C. H. Peck (a large collection now in two packets).

The fungus, as Petrak (1925) noted, is closely related to *Massaria inquinans* (Tode: Fr.) Ces. & de Not. The perithecia are separate and lack the dark marginal zones which delimit those of *M. inquinans* (Barr, 1979a) Fig. 78.

***xanthoxyli*, (*Valsa*)** Peck, Ann. Rep. New York State Mus. 31: 49, 50. (for 1877) 1879.
Pseudovalsa xanthoxyli (Peck) Sacc., Syll. Fung. 2: 137. 1883.
Fenestella xanthoxyli (Peck) Sacc., Syll. Fung. 2: 332. 1883.
Thyronectria xanthoxyli (Peck) Ellis & Everh., N. Amer. Pyrenomyc. p. 92. 1892.
Aglaospora xanthoxyli (Peck) O. Kuntze, Rev. Gen. Pl. 3: 441. 1898.
Type specimen (holotype): on branches of *Xanthoxylum americanum*, West Troy, Rensselaer Co., New York, Oct 1877, C. H. Peck (a large collection now in two packets).

Seeler (1940) accepted the species in *Thyronectria*.

***xylophilus*, (*Hypomyces*)** Peck, Bull. Torrey Bot. Club 11: 28. 1884.
Peckiella xylophila (Peck) Sacc., Syll. Fung. 9: 944. 1891.

Type specimen (holotype): on decaying wood, Ohio, 1883, Morgan.

Hypomyces xylophilus is identical to **Hypomyces armeniacus** Tulasne, Ann. Sci. Nat. Bot. IV. 13: 12. 1860.

LITERATURE CITED

Ames, L. M. 1963. A monograph of the Chaetomiaceae. U. S. Army Res. & Dev. Series 2: 1-65, *30 pl.*

Arx, J. A. von. 1963. Die Gattungen der Myriangiales. Persoonia 2: 421-475.

Arx, J. A. von and E. Müller. 1954. Die Gattungen der amerosporen Pyrenomyceten. Beitr. Kryptogamenfl. Schweiz 11(1): 1-434.

Barr, M. E. 1968. The Venturiaceae in North America. Canad. J. Bot. 46: 799-864.

Barr, M. E. 1976. Perspectives in the Ascomycotina. Mem. New York Bot. Gard. 28: 1-8.

Barr, M. E. 1978. The Diaporthales in North America with emphasis on *Gnomonia* and its segregates. Mycol. Mem. 7: 1-232.

Barr, M. E. 1979a. On the Massariaceae in North America. Mycotaxon 9: 17-37.

Barr, M. E. 1979b. A classification of Loculoascomycetes. Mycologia 71: 935-957.

Barr, M. E. 1980. On the family Tubeufiaceae (Pleosporales). Mycotaxon 12: 137-167.

Barr, M. E. 1983. The ascomycete connection. Mycologia 75: 1- 13.

Barr, M. E. 1984. *Herpotrichia* and its segregates. Mycotaxon 20: 1-38.

Berlese, A. N. 1890. Icones Fungorum, Fasc. I: 1-28 + *pl. I-XVII.*

Berlese, A. N. 1892. Icones Fungorum, Fasc. II: 51-90 + *pl. XXXVIII-LXXXI.*

Bigelow, H. E. and M. E. Barr. 1960. Contribution to the fungus flora of northeastern North America. Rhodora 62: 186-198.

Bigelow, H. E. and M. E. Barr. 1963. Contribution to the fungus flora of northeastern North America. III. Rhodora 65: 289-309.

Bigelow, H. E. and M. E. Barr. 1969. Contribution to the fungus flora of northeastern North America. V. Rhodora 71: 177-203.

Bisby, G. R. 1932. Type specimens of certain Hysteriales. Mycologia 24: 304-329.

Blumer, S. 1967. Echte Mehltaupilze (Erysiphaceae). 436 p. Gustav Fischer Verlag, Jena.

Bose, S. K. 1961. Studies on *Massarina* Sacc. and related genera. Phytopathol. Z. 41: 151-213.

Braun, U. 1984a. Taxonomic notes on some powdery mildews (III). Mycotaxon 19: 369-374.

Braun, U. 1984b. Descriptions of new species and combinations in *Microsphaera* and *Erysiphe*. Mycotaxon 20: 491-498.

Chesters, C. G. C. and A. Bell. 1970. Studies in the Lophiostomatceae Sacc. Mycol. Pap. 120: 1-55.

Clements, F. E. and C. L. Shear. 1931. The genera of fungi. 496 p., *58 pl.* H. W. Wilson Co., New York.

Clinton, G. W. 1866. Facts and observations touching the flora of the State of New York. Ann. Rep. New York State Cab. 19: 72-80.

Cooke, W. B. 1952. Nomenclatural notes on the Erysiphaceae. Mycologia 44: 570-574.

Corbaz, R. 1957. Recherches sur le genre *Didymella* Sacc. Phytopathol. Z. 28: 375-414.

Darker, G. D. 1967. A revision of the genera of the Hypodermataceae. Canad. J. Bot. 45: 1399-1444.

Diehl, W. W. 1950. *Balansia* and the Balansiae in America. Agric. Monogr. U. S. D. A. 4: 1-82. *pl. 1-11.*

Dowding, E. S. 1931. *Wallrothiella arceuthobii*, a parasite of the jack-pine mistletoe. Canad. J. Res. 5: 219-230.

Dreschler, C. 1934. Phytopathological and taxonomic aspects of *Ophiobolus*, *Pyrenophora*, *Helminthosporium*, and a new genus *Cochliobolus*. Phytopathology 24: 953-983.

Ellis, J. B. and B. M. Everhart. 1892. The North American Pyrenomycetes. Newfield, N. J. 793 p.

Eriksson, B. 1974. On Ascomycetes on Diapensiales and Ericales in Fennoscandia. 2. Pyrenomycetes. Svensk Bot. Tidskr. 68: 192-234.

Farr, M. L. 1963. The systematic position of some *Dimeriella* species and associated fungi on Pinaceae. Mycologia 55: 226-246.

Fitzpatrick, H. M. 1920. Monograph of the Coryneliaceae. Mycologia 12: 206-237. *pl. 12-18.*

Fitzpatrick, H. M. 1924. The genus *Fracchiaea*. Mycologia 16: 101-114.

Francis, S. M. 1975. *Anthostomella* Sacc. (Part I). Mycol. Pap. 139: 1-97.

Hahn, G. G. 1947. Analysis of Peck's types of *Meliola balsamicola* and *Asterina nuda*. Mycologia 39: 479-490.

Hawksworth, D. L. 1985. *Kirschsteiniothelia*, a new genus for the *Microthelia incrustans* group. Bot. J. Linn. Soc. 89: 000-000.

Hedjaroude, G. A. 1969. Études taxonomiques sur les *Phaeosphaeria* Miyake et leurs formes voisines (Ascomycètes). Sydowia 22: 57-107). for 1968.)

Höhnel, F. von. 1919. Fragmente zur Mykologie. 1169. = Uber *Didymella sambucina* Rehm. Sitzungsber. Kaiserl. Akad. Wiss., Math.-Naturwiss. Kl. Abt. I. 128: 579-582.

Holm, L. 1957. Etudes taxonomiques sur les Pléosporacées. Symb. Bot. Upsal. 14(3): 1-188.

Holm, L. 1968. Taxonomic notes on Ascomycetes. VI. On the genus *Gibberidea* and some alleged relatives. Svensk Bot. Tidskr. 62: 217-242.

Holm, L. and K. Holm. 1977. A study of the Leptopeltidaceae. Bot. Not. 130: 215-229.

Holm, L. and K. Holm. 1978. Some pteridicolus Ascomycetes. Bot. Not. 131: 97-115.

Hughes, S. J. and G. L. Hennebert. 1963. Microfungi X. Canad. J. Bot. 41: 773-810.

Kendrick, B. (editor). 1971. Taxonomy of Fungi Imperfecti. Univ. Toronto Press. 309 p.

Kobayashi, T. 1970. Taxonomic studies of Japanese Diaporthaceae with special reference to their life-histories. Bull. Gov. Forest Exp. Sta. 226: 1-242.

Kuijt. J. 1969. Observations on *Wallrothiella arceuthobii*, a fungus parasite of dwarf mistletoes. Canad. J. Bot. 47: 1359-1365.

Lohman, M. A. 1934. A cultural and taxonomic study of *Hysterium hyalinum*. Pap. Michigan Acad. Sci. 19: 133-140. (for 1933.)

Mains, E. B. 1957. Species of *Cordyceps* parasitic on *Elaphomyces*. Bull. Torrey Bot. Club 84: 243-251.

Mains, E. B. 1958. North American entomogenous species of *Cordyceps*. Mycologia 50: 169-222.

Martin, P. 1970. Studies in the Xylariaceae: VIII. *Xylaria* and its allies. J. South African Botany 36: 73-138.

Miller, J. H. 1940. The genus *Myriangium* in North America. Mycologia 32: 587-600.

Miller, J. H. 1961. A monograph of the world species of *Hypoxylon*. Univ. Georgia Press. 158 p. + 75 *pl*.

Mirza, J. H. and R. F. Cain. 1969. Revision of the genus *Podospora*. Canad. J. Bot. 47: 1999-2048.

Monod, M. 1983. Monographie taxonomique des Gnomoniaceae. Sydowia Beih. 9: 1-315.

Morelet, M. 1983. Systematique et biologie des *Venturia* infeodes aux peupliers de la section Leuce. Thesis.

Müller, E. 1958. Systematische Bemerkungen uber einige *Venturia*-Arten. Sydowia 11: 79-92. (for 1957.)

Müller, E. and J. A. von Arx. 1962. Die Gattungen der didymosporen Pyrenomyceten. Beitr. Kryptogamenfl. Schweiz 11(2): 1-922.

Nannfeldt, J. A. 1972. *Camarops* Karst. (Sphaeriales- Boliniaceae). Svensk Bot. Tidskr. 66: 335-376.

Nannfeldt, J. A. 1975. Stray studies in the Coronophorales (Pyrenomycetes) 4-8. Svensk Bot. Tidskr. 69: 289-335.

Obrist, W. 1959. Untersuchungen über einige "dothideale" Gattungen. Phytopathol. Z. 35: 357-388.

Paine, J. A. 1865. Catalogue of plants found in Oneida County and vicinity. Ann. Rep. New York State Cab. 18: 53-192.

Parmelee, J. A. 1958. Some foliicolous fungi of the Pyrolaceae. Canad. J. Bot. 36: 865-881.

Peck, C. H. 1866. List of mosses of the State of New York. Ann. Rep. New York State Cab. 19: 43-70.

Petrak, F. 1923. Beiträge zur Pilzflora von Sternberg in Mähren. I. Ann. Mycol. 21: 107-132.

Petrak, F. 1925. Mykologische Notizen. VIII. 495 *a* Über *Massariella xanthoxyli* Peck. Ann. Mycol. 23: 137-138.

Petrak, F. 1934. Mykologische Notizen. XII. 751. *a* Über *Dothidella alni* Peck. Ann. Mycol. 32: 317-318.

Petrak, F. 1940. Mykologische Notizen XII. 911. a Über *Diatrypella discoidea* Cke. et Peck. Ann. Mycol. 38: 240, 919. Über *Valsa truncata* Cooke et Peck. Ann. Mycol. 38: 251.

Petrak, F. 1941. Mykologische Notizen XIV. 950. = Über *Dothidea kalmiae* Peck. Ann. Mycol. 39: 282-283.

Petrak, F. and R. Ciferri. 1930. Fungi dominicani. Ann. Myol. 28: 377-420.

Pirozynski, K. A. and J. Reid. 1966. Studies on the Patellariaceae I. *Eutryblidiella sabina* (de Not). Höhn. Canad. J. Bot. 44: 655-662.

Pomerleau, R. and D. E. Etheridge. 1962. A bluestain in balsam fir. Mycologia 53: 155-170. (for 1961.)

Reid, J. and R. F. Cain. 1960. Additional Diaporthales on twigs from Ontario. Canad. J. Bot. 38: 945-950.

Saccardo, P. A. 1882. Sylloge Fungorum, Vol. I. Patavii.

Salmon, E. S. 1900. A monograph of the Erysiphaceae. Mem. Torrey Bot. Club 9: 1-292.

Samuels, G. J. 1976. A revision of the fungi formerly classified as *Nectria* subgenus *Hyphonectria*. Mem. New York Bot. Gard. 26(3): 1-126.

Seaver, F. J. 1909. The Hypocreales of North America — I. Mycologia 1: 41-76. *pl. 5*. II. 177-207.

Seaver, F. J. 1910. The Hypocreales of North America — III. Mycologia 2: 48-92. *pl. 20-21*. IV. 207-230.

Seeler, E. V., Jr. 1940. A monographic study of the genus *Thyronectria*. J. Arnold Arb. 21: 429-460.

Shoemaker, R. A. 1964. Conidial states of some *Botryosphaeria* species on *Vitis* and *Quercus*. Canad. J. Bot. 42: 1297-1301.

Shoemaker, R. A. 1965. Revision of some *Dimeriella* and *Dimerosporium* parasites of conifers. Canad. J. Bot. 43: 631-639.

Shoemaker, R. A. 1976. Canadian and some extralimital *Ophiobolus* species. Canad. J. Bot. 54: 2365-2404.

Shoemaker, R.A. (1984) 1985. Canadian and some extralimital *Leptosphaeria* species. Canad. J. Bot. 62: 2688-2729.

Sivanesan, A. 1971. The genus *Herpotrichia Fuckel*. Mycol. Pap. 127: 1-37.

Sivanesan, A. 1983. Studies on Ascomycetes. Trans. Brit. Mycol. Soc. 81: 313-332.

Tiffany, L. H. and J. C. Gilman. 1965. Iowa Ascomycetes. IV. Diatrypaceae. Iowa State J. Sci. 40: 121-161.

Torrey, J. 1843. A flora of the State of New York, comprising full descriptions of all the indigenous and naturalized plants hitherto discovered in the State; with remarks on their economical and medicinal properties. Vol. 1: i-xii, 1-484, *pl. 1-72*; vol. 2: 1-572., *pl. 73-161*.

Webster, J. and M. T. Lucas. 1961. Observations on British species of *Pleospora*. II. Trans. Brit. Mycol. Soc. 44: 417-436.

Wehmeyer, L. E. 1933. The genus *Diaporthe* Nitschke and its segregates. Univ. Michigan Press, Ann Arbor. 349 p.

Wehmeyer, L. E. 1941. A revision of *Melanconis*, *Pseudovalsa*, *Prosthecium*, and *Titania*. Univ. Michigan Press, Ann Arbor, 161 p.

Wehmeyer, L. E. 1961. A world monograph of the genus *Pleospora* and its segregates. Univ. Michigan Press, Ann Arbor. 451 p.

Weir, J. R. 1915. *Wallrothiella arceuthobii*. J. Agric. Res. 369-378.

Welch, D. S. 1926. A monographic study of the genus *Cucurbitaria* in North America. Mycologia 18: 51-86.

Vogelenzang, L. (ed.) 1980. Charles Horton Peck; Annual Reports of the State Botanist 1868-1912. Vol. 1.

Zogg, H. 1943. Untersuchungen über die Gattung *Hysterographium* Corda, insbesondere über *Hysterographium fraxini* (Pers.) de Not. Phytopathol. Z. 14: 310-384.

Zogg, H. 1962. Die Hysteriaceae s. str. und Lophiaceae. Beitr. Kryptogamenfl. Schweiz 11(3): 1-190.

Legends for Figures

Figs. 1-15:

1. *Myriangium superficialis*: ascospores.

2-4. *Arthothelium lichenalis*: 2. ascoma, side view; 3. ascus; 4. ascospores.

5-7. *Leptopeltis subconfluens*: 5. ascomata, side and top views; 6. ascus; 7. ascospores.

8-10. *Hysterostomella sparsa*: 8. ascoma, top view; 9. ascus and upper cells; 10. ascospores.

11-12. *Tryblidaria fenestrata*: 11. portion of ascoma, side view; 12. ascospores.

13-15. *Trichothyrina tracyi*: 13. ascoma, surface view; 14. ascus; 15. ascospores.

Scale line = 100 μm for Figs. 2, 5, 8, 11; 16 μm for other figures.

Figs. 16-29:

16-18. *Cucurbitaria interstitialis*: 16. ascoma, side view; 17. ascus; 18. ascospores.

19. *Melanomma rhododendri*: ascospores from type specimen of *Leptosphaeria kalmiae*.

20-22. *Cucurbitaria longitudinalis*: 20. ascoma, side view; 21. ascus; 22. ascospores.

23-25. *Neodeightonia ramulicola*: 23. ascomata, side view; 24. ascus; 25. ascospores.

26-27. *Phaeosphaeria clavispora*: 26. ascomata, end and long views; 27. ascospores.

28-29. *Phaeosphaeria corallorhizae*: 28. ascoma, side view; 29. ascospores.

Scale line = 200 μm for Figs. 16, 20, 23; 100 μm for Figs. 26, 28; 16 μm for other figures.

Figs. 30-46:

30-32. *Teichospora aridophila*: 30. ascoma, side view; 31. ascus; 32. ascospores.

33-34. *Fenestella erratica*: 33. ascoma, side view; 31. ascospores.

35-36. *Byssosphaeria alnea*: 35. ascomata, side view; 36. ascospores.

37-38. *Byssosphaeria salebrosa*: 37. ascoma, side view; 38. ascospores.

39-41. *Byssosphaeria semen*: 39. ascoma, side view; 40. ascus; 41. ascospores.

42-44. *Bertiella rhodospila*: 42. ascoma, side view (from type specimen of *Melogramma effusa*); 43. ascospores (same); 44. ascospores (from isotype specimen of *Sphaeria rhodospila*).

45-46. *Herpotrichia macrotricha*: 45. ascoma, side view; 46. ascospores (from type specimen of *Herpotrichia albidostoma*).

Scale line = 200 μm for Figs. 30, 33, 35, 37, 39, 42, 45; 16 μm for other figures.

Figs. 47-66:

47-49. *Kirschsteiniothelia recessa*: 47. ascoma, side view; 48. ascus; 49. ascospores.

50. *Kirschsteiniothelia phileura*: ascospores.

51. *Asteromassaria minor*: ascospores.

52-53. *Karstenula shepherdiae*: 52. ascoma, side view; 53. ascospores.

54-55. *Sporormiella sorghophila*: 54. ascoma, side view; 55. ascospores.

56-57. *Pleomassaria monosperma*: 56. ascoma, side view; 57. ascus containing immature ascospore.

58-59. *Caliciopsis arceuthobii*: 58. ascus; 59. young and mature ascospores.

60-62. *Rhynchostoma rubefaciens*: 60. outline of perithecium; 61. asci and paraphyses; 62. ascospores.

61-65. *Jattaea ceanothina*: perithecium, side view; 64. ascus; 65. ascospores.

66. *Romellia cornina*: ascospores.

Scale line = 200 μm for Figs. 52, 56, 60, 63; 100 μm for Figs. 47, 54; 16 μm for other figures.

Figs. 67-86:

67-69. *Niesslia pulchriseta*: 67. perithecium, surface view; 68. ascus; 69. ascospores.

70-71. *Litschaueria longipila*: 70. ascus; 71. ascospores.

72-74. *Phaeotrichosphaeria caesariata*: 72. perithecium, outline; 73. ascospores; 74. associated conidial fungus.

75-77. *Hyponectria depressa*: 75. perithecia, outline; 76. ascus; 77. ascospores.

78. *Massaria xanthoxyli*: ascospores.

79-80. *Endoxylina moroides*: 79. ascus; 80. ascospores.

81-83. *Jattaea curvicolla*: 81. perithecia, outline; 82. ascus; 83. ascospores.

84-86. *Anthostomella adusta*: 84. perithecium, outline; 85. ascus apex; 86. ascospores.

Scale line = 100 µm for Figs. 72, 75; 16 µm for other figures.

Figs. 87-103:

87-89. *Ophiovalsa trichispora*: 87. perithecium, side view; 88. ascus; 89. ascospores.

90. *Plagiostoma mirabilis*: ascospores.

91-93. *Ceratostomella subdenudata*: 91. perithecium, surface view; 92. ascus; 93. ascospores.

94-96. *Ditopellopsis racemula*: 94. perithecia, side view; 95. ascus; 96. ascospores.

97. *Cryptodiaporthe petiolophila*: ascospores.

98-100. *Mamianiella coryli* var. *spiralis*: 98. perithecium, surface view; 99. ascus; 100. ascospores.

101-103. *Chapeckia nigrospora*: 101. perithecia in stroma, side view; 102. ascus; 103. ascospores.

Scale line = 400 µm for Figs. 91, 101; 200 µm for Fig. 94; 100 µm for Figs. 87, 98; 16 µm for other figures.

Figs. 104-132:

104. *Valsa acerina*, holotype: substrate, perithecia, ascospores.

105. *Xylaria acuta*, holotype: stroma, perithecia, asci, ascospores.

106. *Valsa alni*, holotype: substrate, perithecia top view, perithecia side view, asci, ascospores.

107. *Sphaerella alnicola*, holotype: substrate, perithecia, asci, ascospores.

108. *Nectria apocyni*, holotype: substrate, perithecia, ascus, ascospores.

109. *Diatrype betulina*, holotype: substrate, perithecia side view, asci, ascospores.

110. *Venturia pulchella*, isolectotype: substrate, perithecium, asci, ascospores.

111. *Venturia compacta*, holotype: substrate, perithecia, asci, ascospores.

112. *Venturia curviseta*, holotype: substrate, perithecium, setum, asci, ascospores.

113. *Diaporthe farinosa*, holotype: substrate, perithecia, asci, ascospores.

114. *Valsa femoralis*, holotype: substrate, perithecia, ascus, ascospores.

115. *Xylaria grandis*, holotype: stroma, perithecia, ascus, ascospores.

116. *Hypoxylon howeianum*, presumably from type: substrate with stroma, stroma with perithecia, ascus, ascospores.

117. *Valsa impulsa*, from specimen labelled "Adirondack Mtns.": ascus, ascospores.

118. *Hysterium macrosporium*, holotype: substrate with ascomata, ascus, ascospores.

119. *Lophiostoma magnatum*, holotype: substrate, perithecium, ascospores.

120. *Chaetomium melioloides*, holotype: substrate, perithecium, appendage, ascospores.

121. *Lophiotrema parasitica*, presumably from type: perithecia in substrate, single perithecium, ascus, ascospores.

122. *Sphaeria parnassiae*, holotype: substrate, ascospores.

123. *Sphaeria petiolophila*, holotype: perithecium, asci, ascospores.

124. *Diatrype platasca*, holotype: substrate, perithecia in substrate, perithecia in side view, asci, ascospores.

125. *Hypomyces polyporinus*, presumably from type: perithecium, ascus, ascospores.

126. *Valsa sambucina*, holotype: ascus, ascospores.

127. *Sphaeria staphylina*, holotype: substrate, ascus, ascospores.

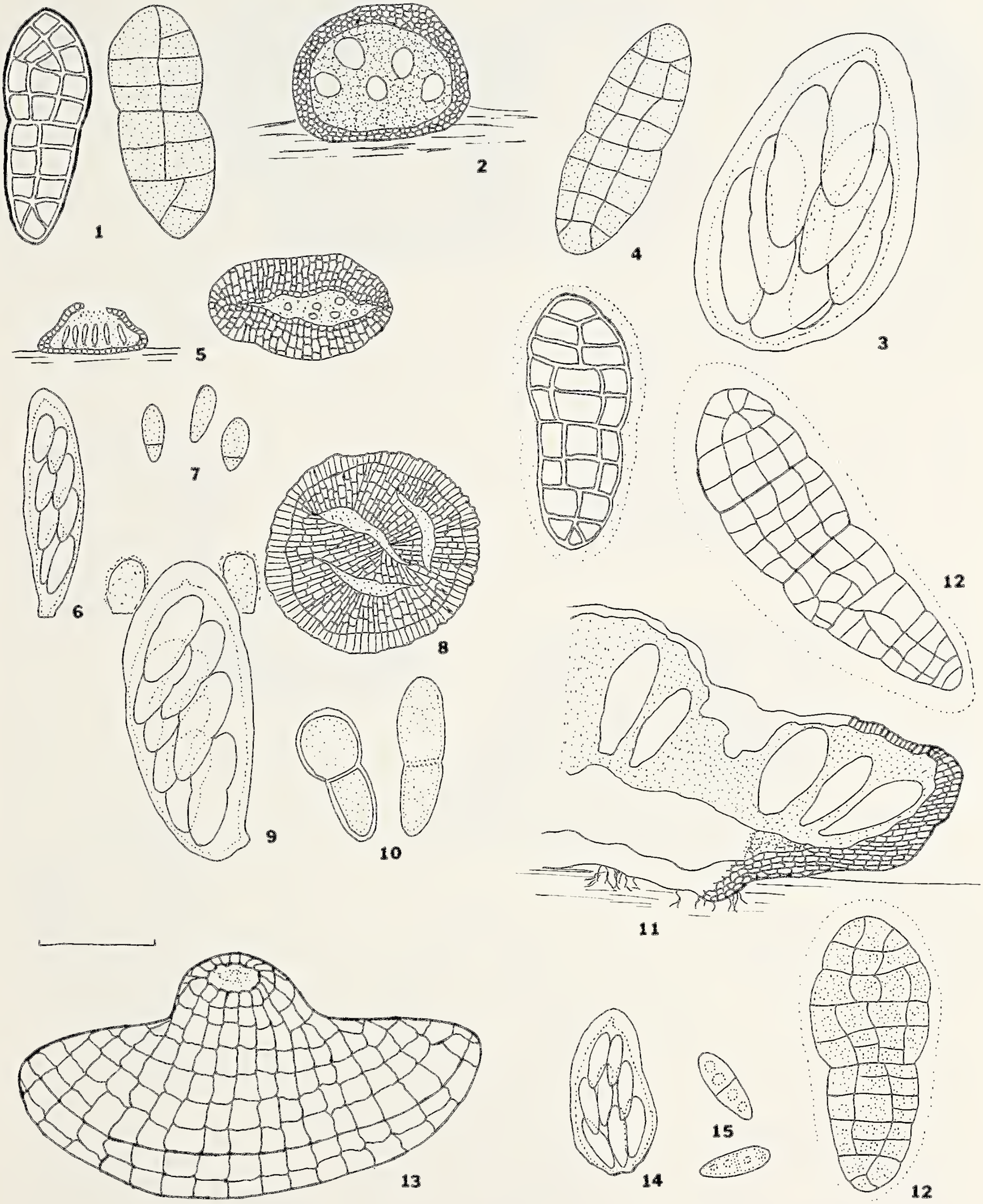
128. *Sphaeria taxicola*, holotype: substrate, perithecium side view, perithecia top view, asci, ascospores.

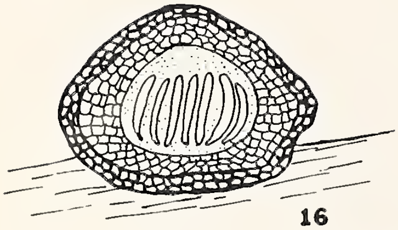
129. *Valsa thujae*, holotype: substrate, asci, ascospores.

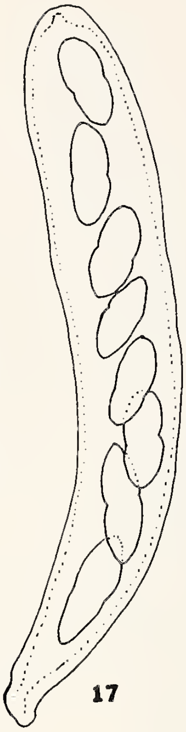
130. *Lophiostoma triseptata*, lectoparatype: ascus, ascospores.

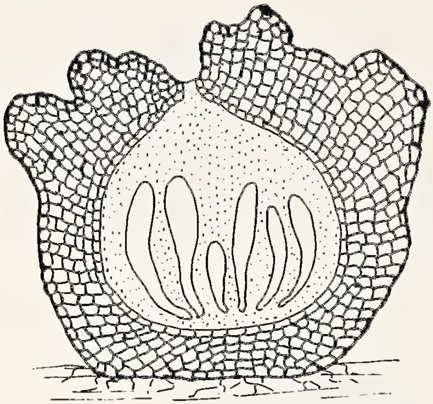
131. *Microsphaera vaccinii*, West Albany, Oct.: perithecium with appendages, perithecium with asci.

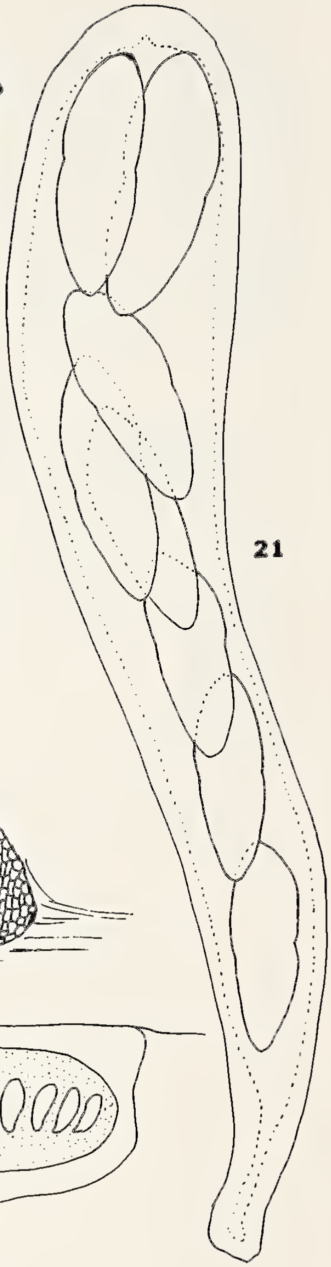
132. *Leptosphaeria variegata*, holotype: substrate, perithecium, asci, ascospores.

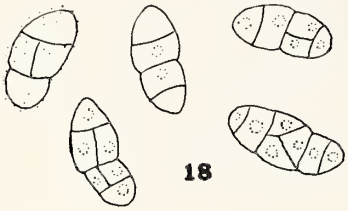


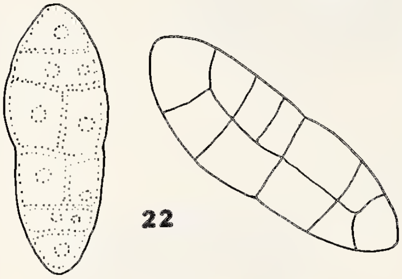

16

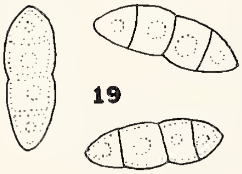

17

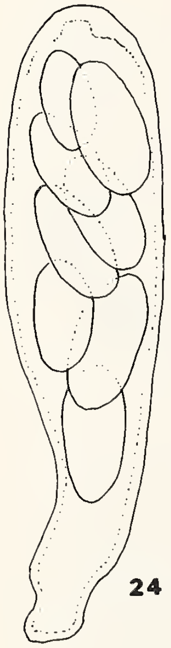

20

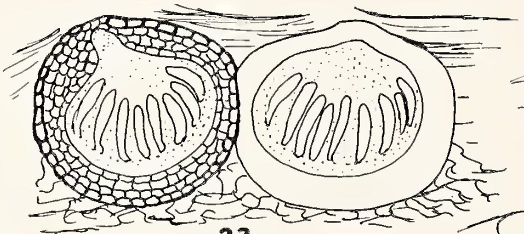

21

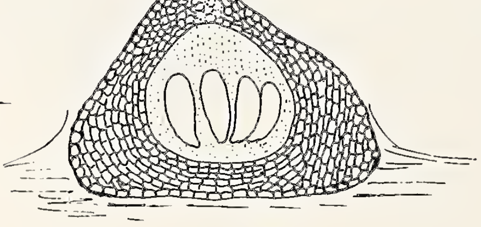

18

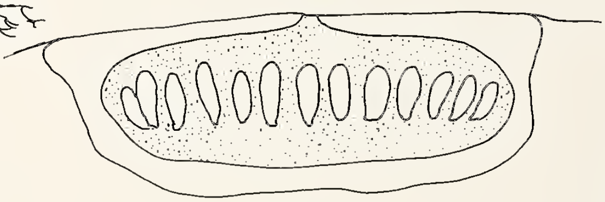

22

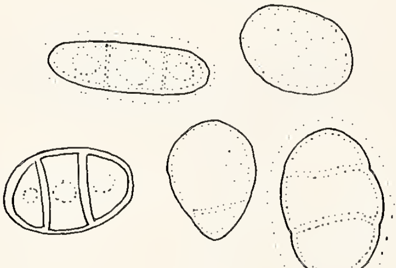

19

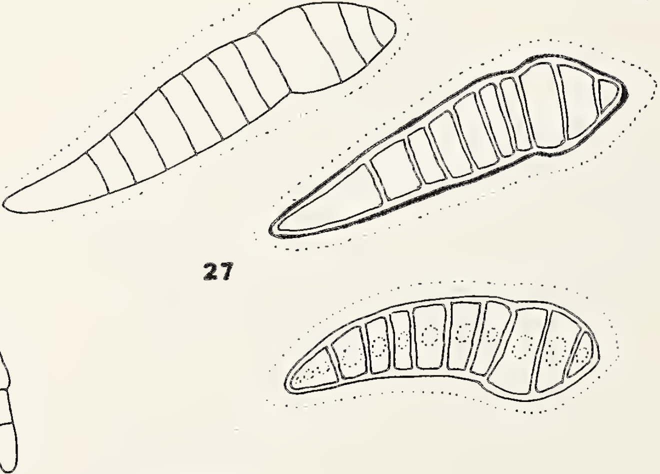

24

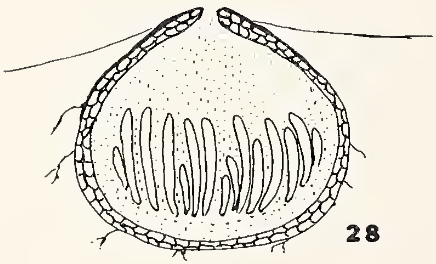

23

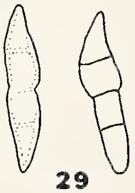

26

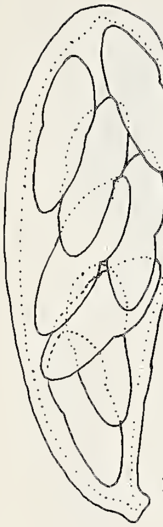


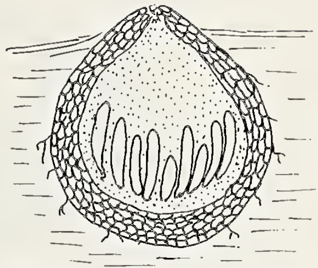

25

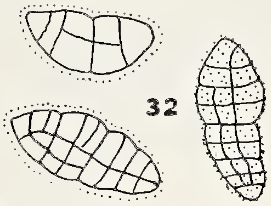

27

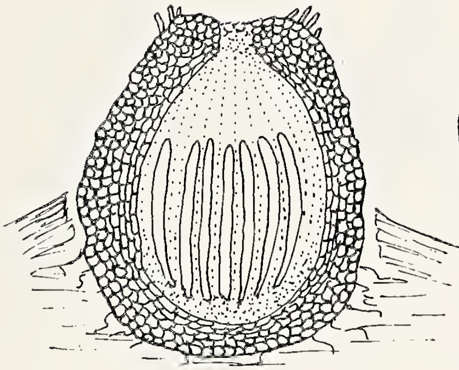

28

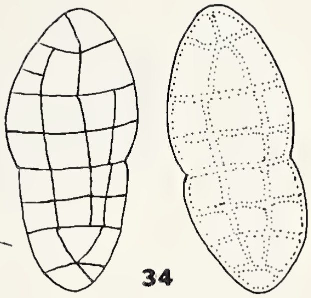

29

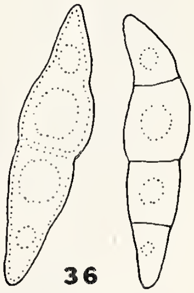

31

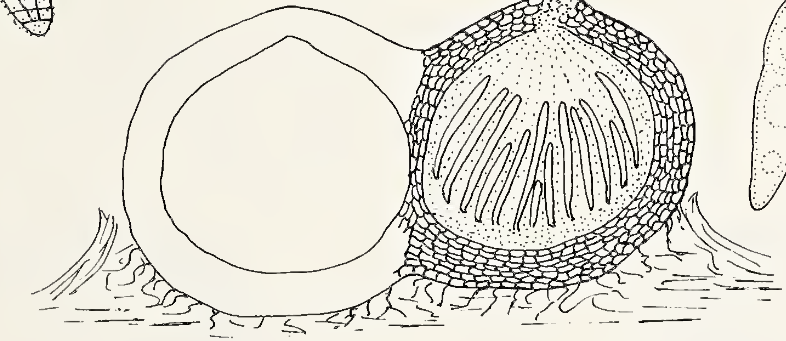

30

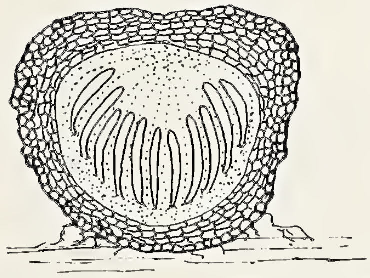

32

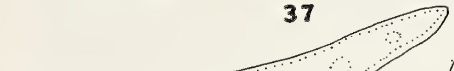
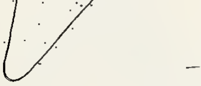

33

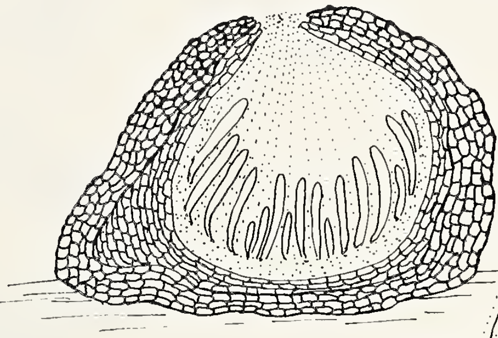

34

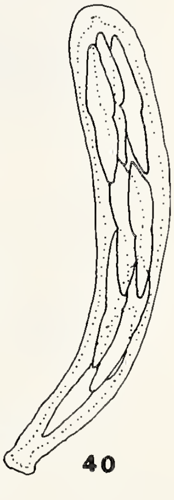

36

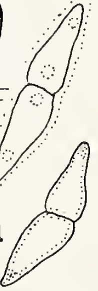

35

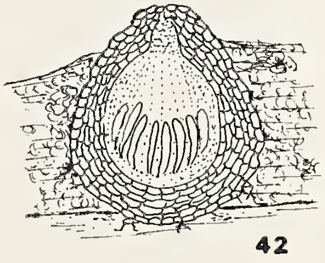

37

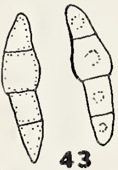


38

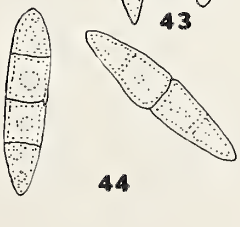

39

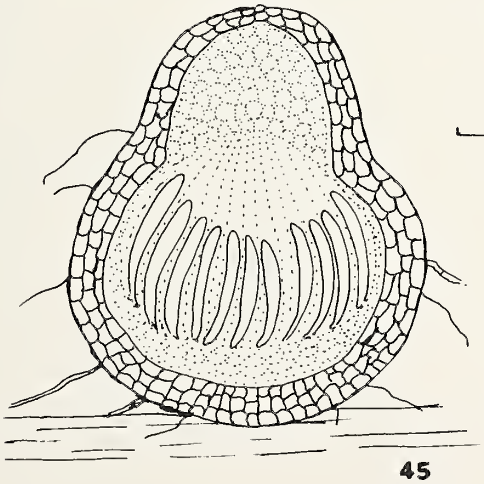

40

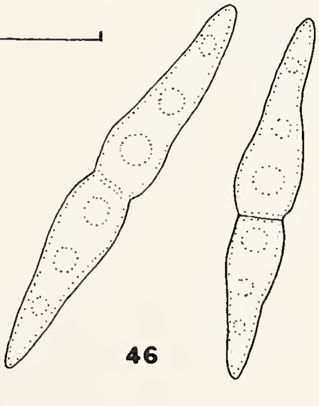

41

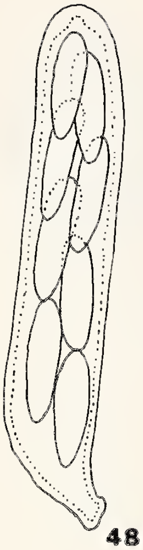

42


43

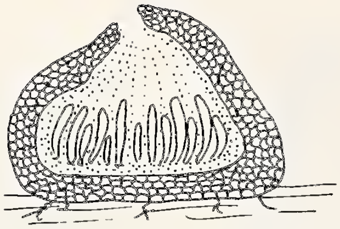

44


45

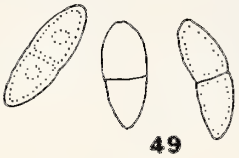

46



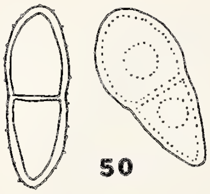
48



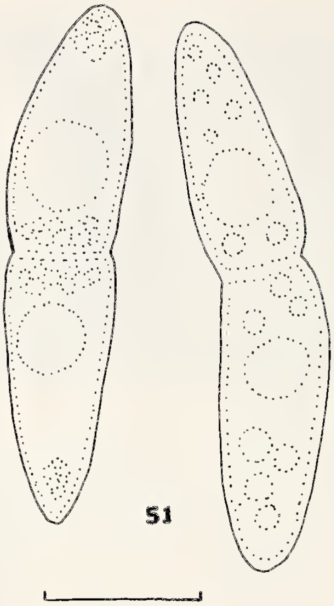
47



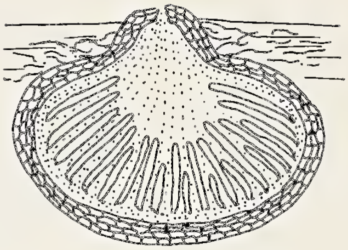
49



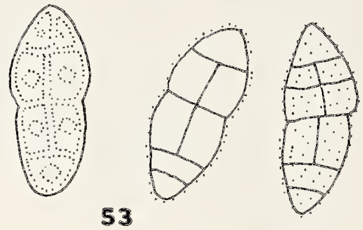
50



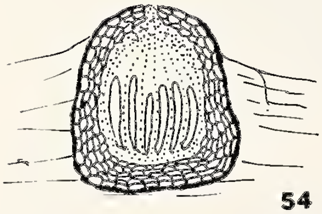
51



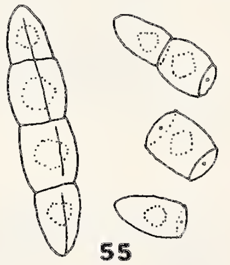
52



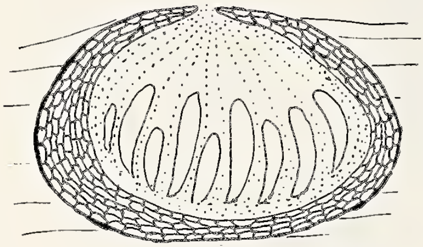
53



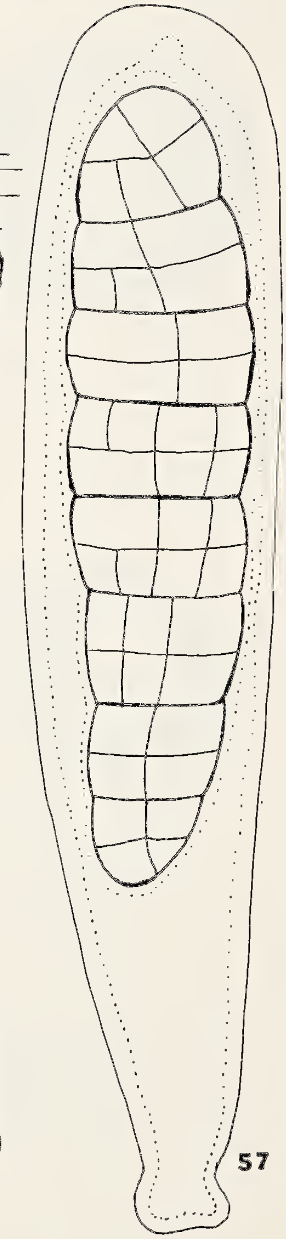
54



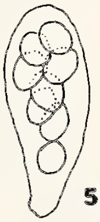
55



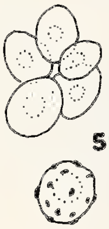
56



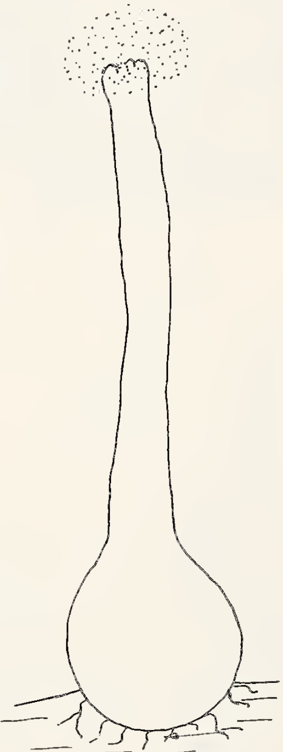
57



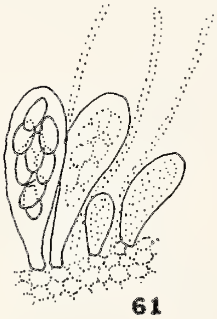
58



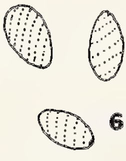
59



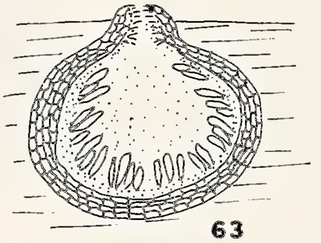
60



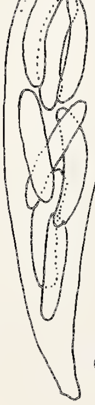
61



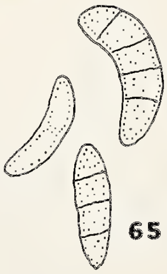
62



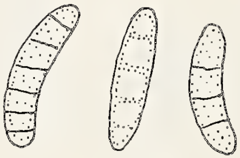
63



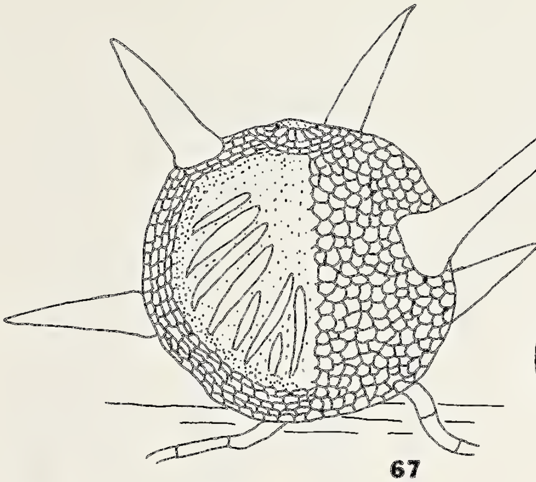
64



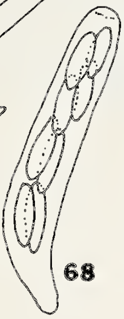
65



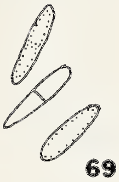
66



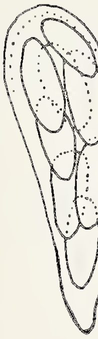
67



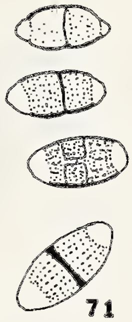
68



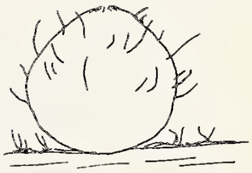
69



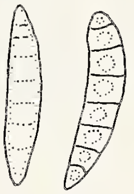
70



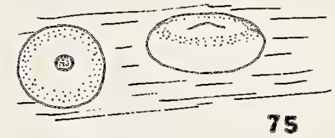
71



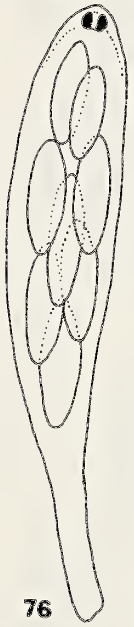
72



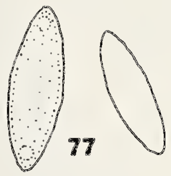
73



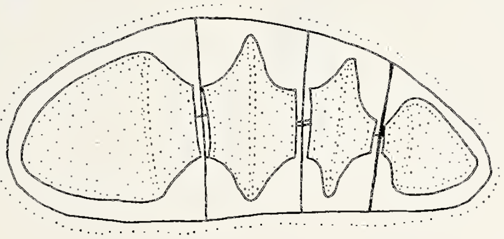
75



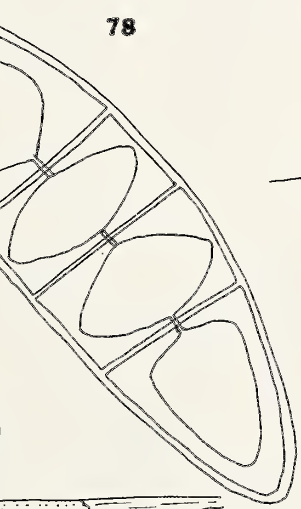
76

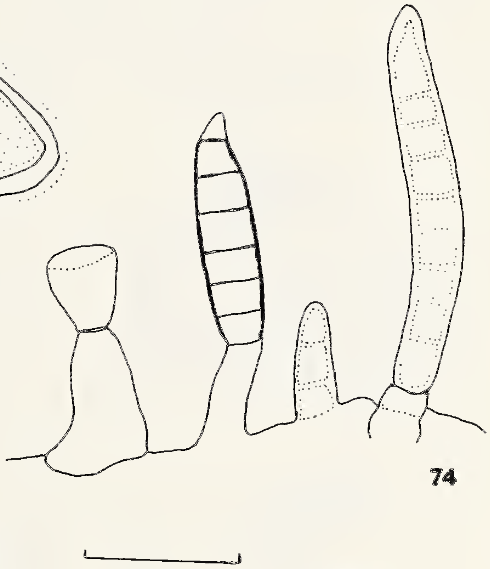


77

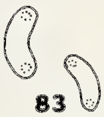


78

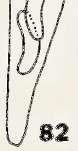




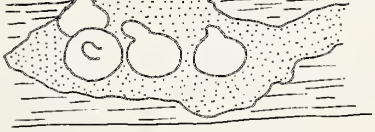
74



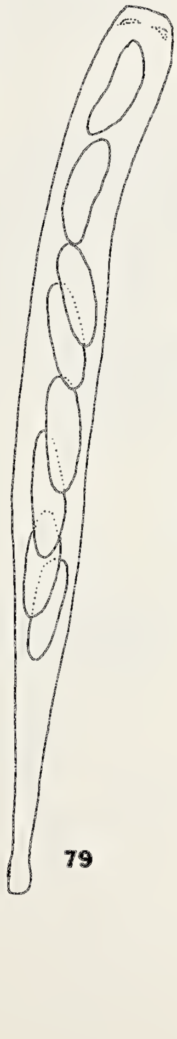
83



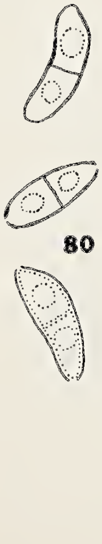
82



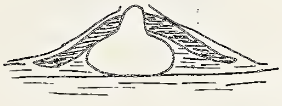
81



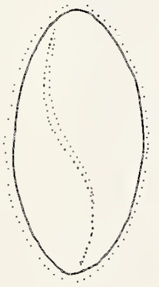
79

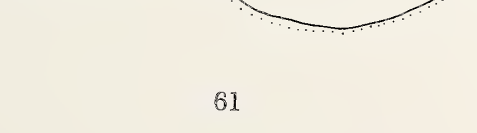


80

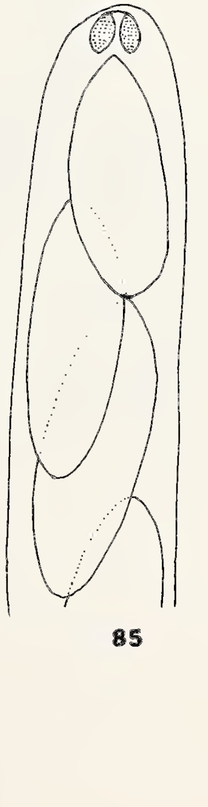


84

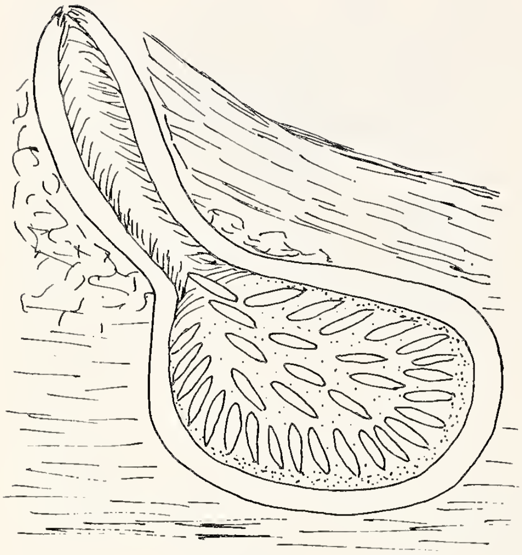


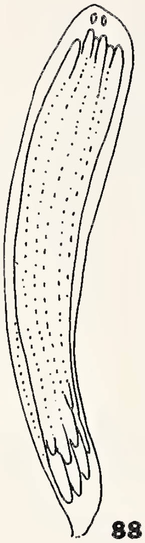


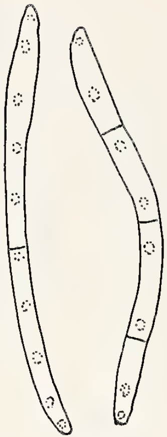
86

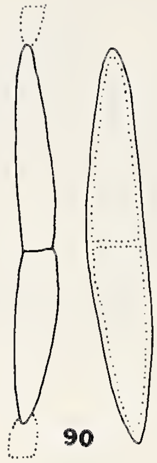


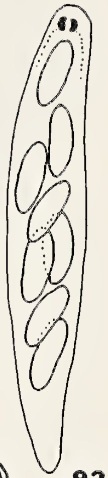
85

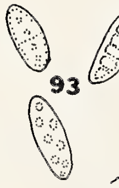

87

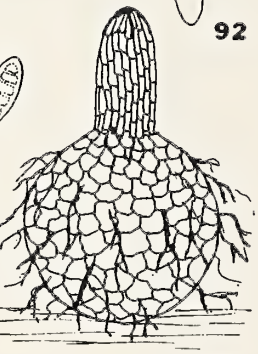

88

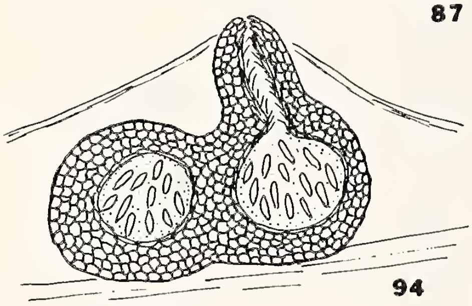

89

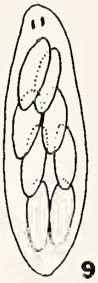

90

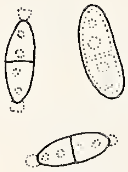

92

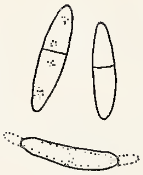

93

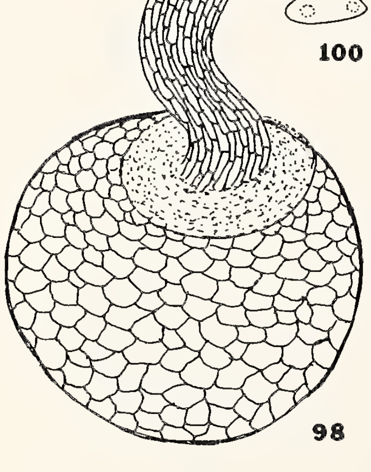

91

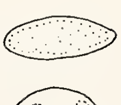

94

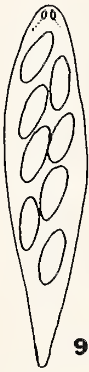

95

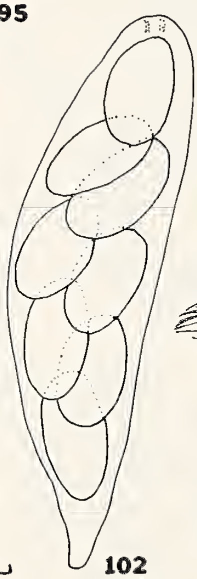

96

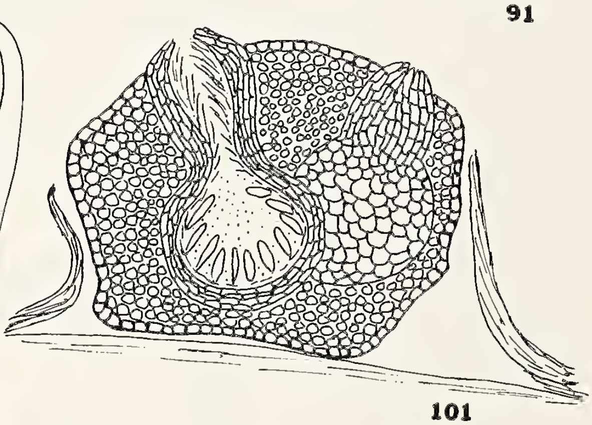

97

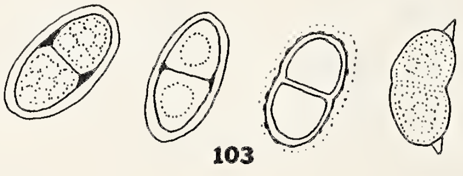

98

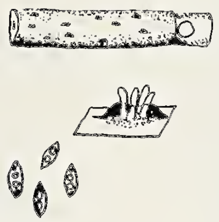

100

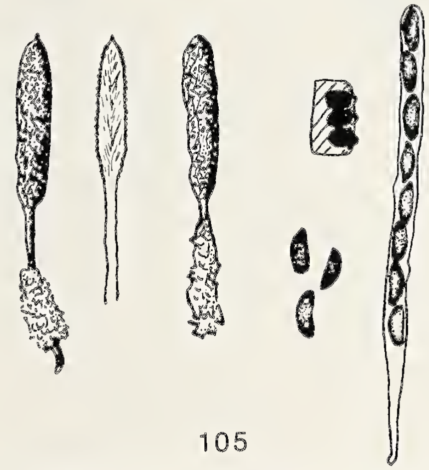

99

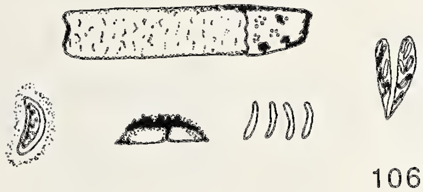

102

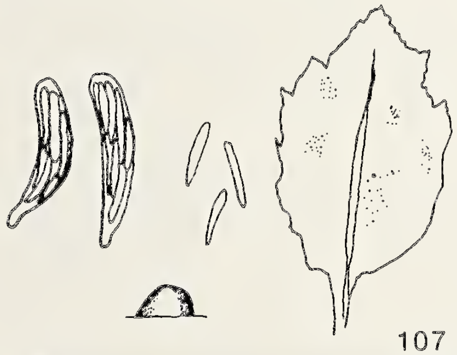

101

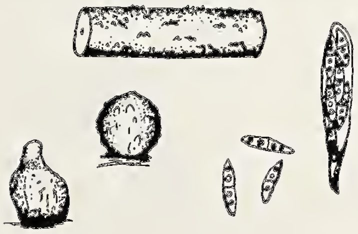

103

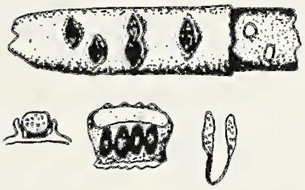

104

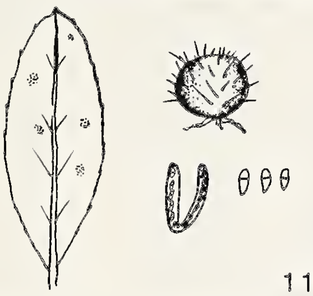

105

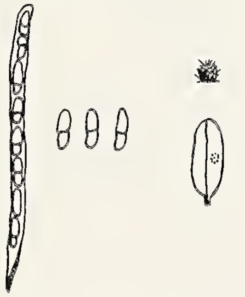

106

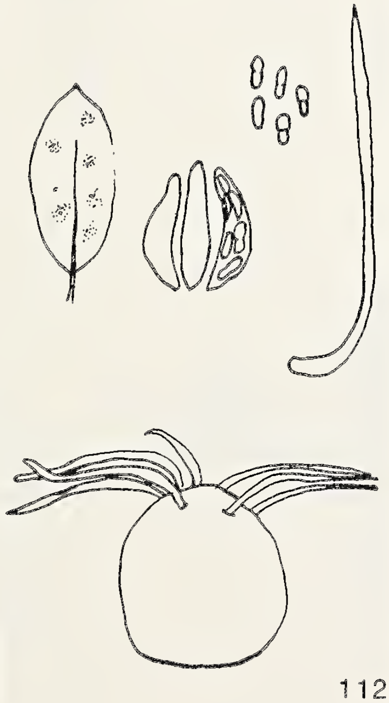

107

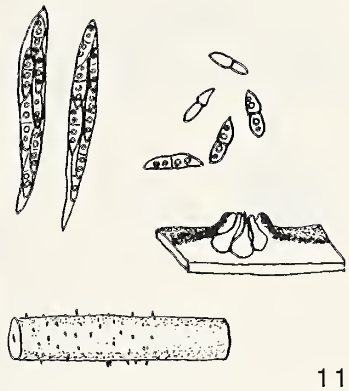

108

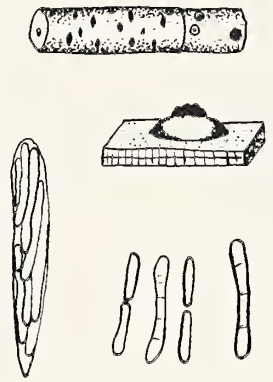

109

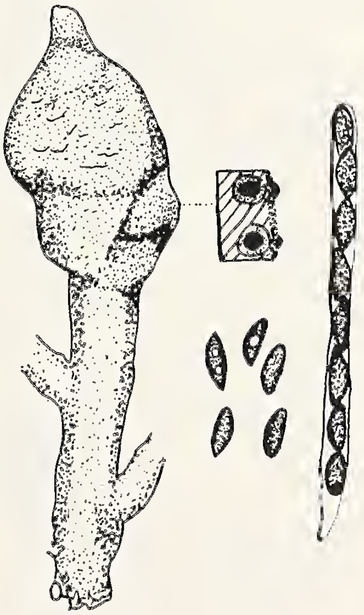

110

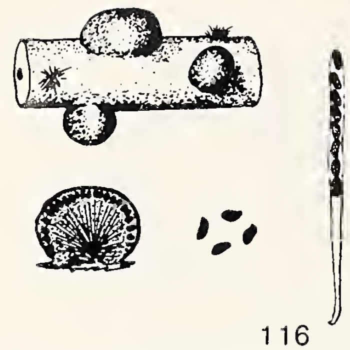

111


112

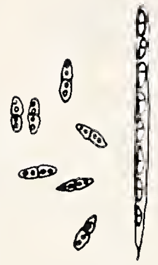

113


114

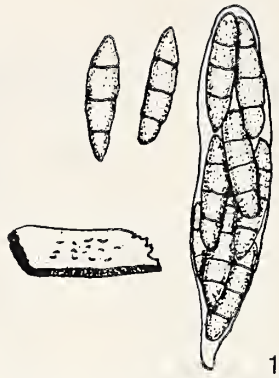

115



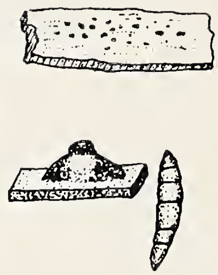
116



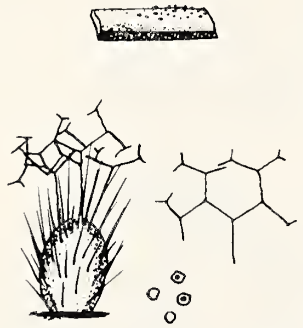
117



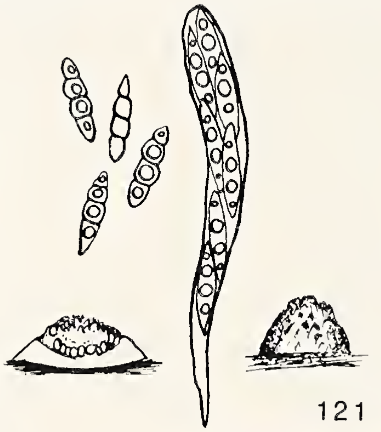
118



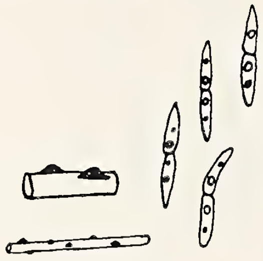
119



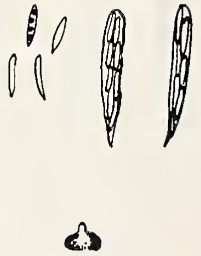
120



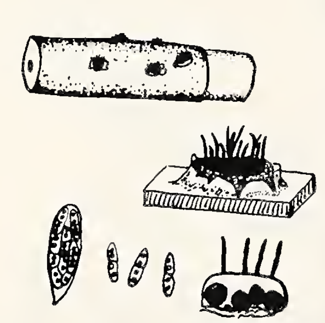
121



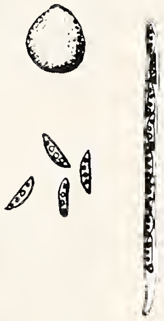
122



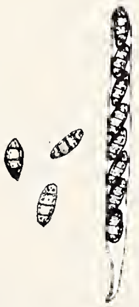
123



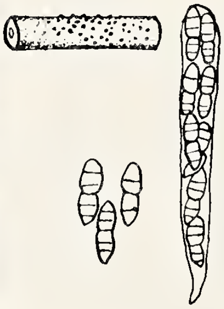
124



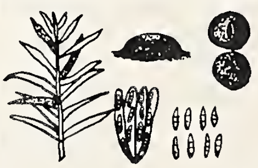
125



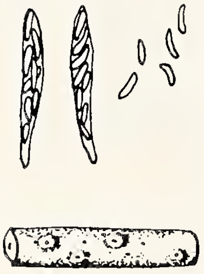
126



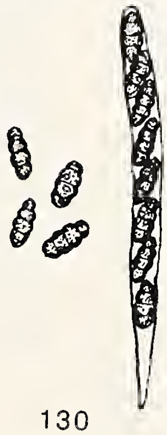
127



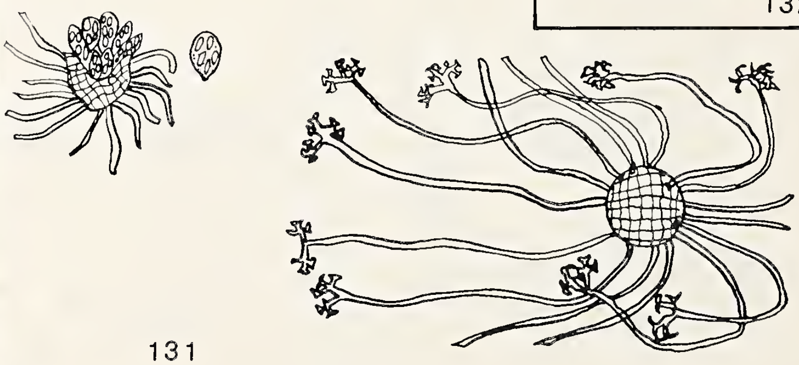
128



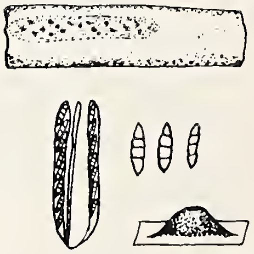
129



130



131



132

Index to Fungus Taxa

(Names in boldface indicate new combinations)

Acanthostigma clintonii 15, 41
  A. pulchrisetum 37
  A. scopula 41
Acrospermum album 7
Adelopus nudus 32
Aglaospora sambucina 40
  A. xanthoxyli 49
Albugo pruinosa 37
Allantoporthe tessella 31
Amphiporthe aculeans 26
Amphisphaeria bufonia 9
  A. phileura 35
  A. salebrosa 40
  A. thujina 46
Anisogramma anomala 8
Antennularia curviseta 17
Anthostoma adustum 6
  A. ellisii var. exudans 21
  A. microsporum var. exudans 21
  A. pulviniceps 38
Anthostomella adusta 6
  A. smilacinina 42
Apiocrea boletina 11
Apioporthe anomala 8
  A. obscura 33
  A. vepris 33
Apiorhynchostoma curreyi 8
Apodothina pringlei 36
Arthothelium lichenalis 27
Ascomycetella quercina 38
Asterella nuda 32
Asterina nuda 32
Asterula tracyi 46
Atkinsonella hypoxylon 25
Auerswaldia pringlei 36
Aulographum ledi 27
  A. subconfluens 44
Balansia hypoxylon 25
Barya parasitica var. caespitosa 34
Berlesiella nigerrima 20, 38
Bertiella rhodospila 19
Blitrydium fenestratum 22
  B. platascum 36
Botryosphaeria aesculi 7
  B. dasylirii 18
  B. festucae 18
  B. quercuum 18
  B. smilacinina 42
Bruneaudia clavispora 14
Byssosphaeria alnea 7
  B. rhodomphala 39
  B. salebrosa 40
  B. schiedermayeriana 40
  B. semen 41
Caliciopsis arceuthobii 9
  C. pinea 35
Calonectria balsamea 10
Calospora clavispora 14
Camarops microspora 22
Caryospora minor 30
Cenangella deformata 18
Cenangium asterinosporum 45
  C. deformatum 18
  C. platascum 36
Ceratostoma rubefaciens 39
  C. subdenudata 44
Ceratostomella subdenudata 44
Cercidospora sphaerellula 43
Cercospora borreriae 46
Chaetomium contortum 16
  C. globosum 26
  C. indicum 30
  C. lanosum 26
  C. melioloides 30
Chaetoplea calvescens 21
Chaetosphaerella fusca 35
Chaetosphaeria leonina 27
  C. longipila 28
  C. phaeostroma var. phaeostromoides 35
  C. phaeostromoides 35
Chapeckia nigrospora 32
Chilonectria callista 12
Chorostate atropuncta 9
  C. inornata 25
Chromocrea gelatinosa 49
Claussenomyces atrovirens 38
Clintoniella apiculata 8
Cocconia sparsa 42
Coleroa kalmiae 26
Comoclathris permunda 18
Coniochaeta malacotricha 24
Coniothyrium 42
Cookella microscopica 38
  C. quercina 38
Cordyceps capitata 32
  C. clavulata 15
  C. nigriceps 32
  C. superficialis 45

Corynella atrovirens 38
Cryptodiaporthe aculeans 26
  C. petiolophila 35
  C. racemula 38
  C. vepris 33
Cryptopus nudus 32
Cryptosphaeria eunomioides 26
Cryptospora anomala 8
  C. caryae 13
  C. cinctula 14
  C. corylina 45
  C. femoralis 22
  C. leptasca 27
  C. paucispora 35
  C. pulviniceps 38
  C. suffusa var. nuda 45
  C. tomentella 46
  C. trichispora 46
Cryptosporella anomala 8
  C. leptasca 27
  C. paucispora 34
Cucurbitaria alnea 7
  C. apocyni 8
  C. balsamea 10
  C. callista 12
  C. celastri 13
  C. conigena 16
  C. erratica 20
  C. interstitialis 26
  C. longitudinalis 28
  C. seriata 41
Dactylospora stygia var. stygia 23
Delphinella tsugae 16
Dendropleella hirta 30
Dermatella deformata 18
  D. hamamelidis 24
Dermea hamamelidis 24
Diapleella clivensis 30
  D. coniothyrium 30
Diaporthe acerina 6, 7
  D. albocincta 7
  D. arctii 19
  D. atropuncta 9
  D. bicincta 11
  D. binoculata var. magnoliae-acuminatae 11
  D. callicarpae 12
  D. cylindrospora 17
  D. desmodii 18
  D. dubia 39
  D. eres 32, 33, 49
  D. exercitalis 21
  D. farinosa 22
  D. impulsa 25
  D. inornata 25
  D. linearis 21
  D. marginalis 29
  D. mucronata 31
  D. neilliae 32
  D. obscura 33
  D. oxyspora 34
  D. peckii 42
  D. platasca 36
  D. prunicola 17, 37
  D. racemula 38
  D. robusta 39
  D. sociabilis var. sambuci 12
  D. sparsa 42
  D. spiculosa 11, 12
  D. tessella 31
  D. tiliacea 10
  D. tuberculosa var. dispersa 47
  D. tuberculosa var. tuberculosa 47
  D. woolworthii 49
Diaporthella aristata 36
  D. platasca 36
Diatrype adusta 6
  D. albopruinosa 47, 48
  D. angulare 8
  D. anomala 8
  D. betulina 11
  D. brunnea 11
  D. cercidicola 45
  D. discoidea 19
  D. elliptica 20
  D. moroides 31
  D. nigrospora 32
  D. obesa 11
  D. platasca 36
  D. quadrata 11
  D. tumidella 47
  D. verrucoides 48
Diatrypella betulina 11
  D. decorata 6, 11, 19
  D. discoidea 19
  D. favacea 6
  D. frostii 23
  D. underwoodii 47
Didymella applanata 40
  D. onosmodina 33
  D. sphaerellula 43
Didymosphaeria atrogrisea 9
  D. futilis 47
  D. parnassiae 34
  D. typhae 47
Dimeriella balsamicola 10
Dimerium balsamicola 10
Dimerosporium balsamicola 10
Discostroma corticola 24

Ditopellopsis clethrae 38
  D. racemula 38
Dothichloe hypoxylon 25
Dothidea clavispora 14
  D. dalibardae 18
  D. dasylirii 18
  D. episphaeria 20
  D. kalmiae 26
  D. osmundae 33
  D. pringlei 36
  D. rimincola 39
Dothidella alni 7
  D. kalmiae 26
  D. osmundae 33
Dothiora platasca 36
  D. rimincola 39
  D. sambucina 40
  D. staphylina 43
  D. taxicola 45
Dothivalsaria megalospora 8
Elsinoe ledi 27
Enchnoa subcorticalis 44
Enchnosphaeria coulteri 17
Endophragmiella socia 12
Endoxylina moroides 31
Engizostoma alni 7
  E. breve 11
  E. fraxinicola 23
  E. griseum 24
  E. innumerabile 25
  E. linderae 28
  E. longirostre 28
  E. opulifoliae 33
  E. subclypeatum 44
  E. tumidulum 47
Entosordaria altipeta 8
Epichloe hypoxylon 25
Eriosphaeria pulchriseta 37
Erysiphe aggregata 7
  E. alni 35
  E. ceanothi 13
  E. densissima 18
  E. euphorbiae 20
  E. syringae 23
Erysiphella aggregata 7
Eutypa curvicolla 17
  E. ludibunda 25
Eutypella fraxinicola 23
  E. innumerabilis 25
  E. linderae 28
  E. longirostris 28
  E. ludibunda 23
  E. prunastri 47
  E. scoparia 28
  E. stellulata 25
  E. tumidula 47
Fenestella erratica 20
  F. superficialis 45
  F. xanthoxyli 49
Flageoletia leptasca 27
Fracchiaea callista 12
Gibbera cassandrae 13
  G. compacta 15
  G. kalmiae 26
  G. pulchella 37
Gibberidea alnea 7
  G. kalmiae 26
  G. longitudinalis 28
Gloniella hyalina 24
Gnomonia petiolophila 35
Gnomoniella curyicolla 17
  G. eccentrica 19
Guignardia depressa 18
  G. smilacinae 42
Helminthosphaeria clavariae 14
Heptameria clavicarpa 15
  H. sorghophila 42
Herpotrichia albidostoma 7, 27
  H. coulteri 17
  H. leucostoma 7, 27
  H. macrotrichia 7
  H. rhodospila 19
  H. rhodospiloides 39
  H. rhodosticta 39
  H. schiedermayeriana 7
Holmiella sabina 18
Holwaya leptosperma 27
  H. mucida subsp. mucida 27
Hyopomyces volemi 49
Hypocrea apiculata 8
  H. aurantiaca 10
  H. chromosperma 14
  H. gelatinosa 14, 49
  H. hypoxylon 25
  H. latizonata 27
  H. pallida 10
  H. patella 34
  H. viridis 49
Hypocrella hypoxylon 25
Hypolyssus polyporinus 36
Hypomyces apiculatus 8
  H. armeniacus 8, 50
  H. aureonitens 31
  H. banningiae 10, 24
  H. boletinus 11
  H. camphorati 12
  H. chrysospermus 11
  H. chrysospermus var. boletinus 11

  H. hyalinus 25
  H. inaequalis 25
  H. lactifluorum 10, 38
  H. lateritius 25, 49
  H. polyporinus 36
  H. purpureus 38
  H. transformans 46
  H. volemi 49
  H. xylophilus 49
Hyponectria depressa 18
Hypoxylon bartholomaei 11
  H. howeianum 24
  H. rubiginosum 45
  H. sassafras 28
  H. suborbiculare 45
Hysteriographium mori 49
Hysterium clavisporum 14
  H. cubense 17
  H. exaridum 21
  H. gerardii 23
  H. hyalinum 24
  H. macrosporium 29
  H. pulicare 29, 47
  H. staphylina 43
  H. teres 47
  H. thujarum 46
  H. truncatulum 47
  H. variabile 48
  H. viticolum 49
Hysterographium acerinum 6
  H. elongatum 6
  H. gerardii 24
  H. mori 24, 48
  H. variabile 48
  H. viticolum 49
Hysterostomella sabalicola 43
  H. sparsa 43
Jattaea ceanothina 13
  J. curvicolla 17
  J. monosperma 31
Karschia deformata 18
  K. fusispora 23
Karstenula shepherdiae 42
Kirschsteiniella thujina 46
Kirschsteiniothelia aethiops 35
  K. recessa 39
  K. thujina 46
Lactarius volemus 49
Laestadia aesculi 6
  L. depressa 18
  L. smilacinae 42
Lasiosphaeria acicola 17
  L. caesariata 12
  L. coulteri 17
  L. scopula 41
  L. viridicoma 48
Lecanidion atratum 25
  L. hamamelidis 24
  L. indigotica 25
  L. leptospermum 27
  L. pusillum 38
Leptopeltis lunariae 44
  L. subconfluens 44
Leptosphaeria asparagi 9
  L. clavicarpa 15
  L. corallorhizae 16
  L. doliolum 44
  L. drechsleri 23
  L. eutypoides 21
  L. fulgida 23
  L. inquinans 26
  L. kalmiae 26
  L. lycopodiicola 28
  L. lycopodina 29
  L. lythri 29
  L. marciensis 29
  L. myricae 26
  L. ogilviensis 45
  L. pratensis 48
  L. ramulicola 38
  L. saccharicola 40
  L. scapophila 41
  L. sorghophila 42
  L. subconica 44
  L. substerilis 45
  L. taxicola 45
  L. variegata 48
  L. viridella 48
Leucostoma auerswaldii 44
  L. kunzei 11
Litschaueria longipila 28
Lohwagiella pulchriseta 37
Lophidium obtectum 33
Lophiostoma alpigenum 43
  L. angustilabrum 41
  L. angustilabrum var. parasiticum 34
  L. caudatum 37
  L. magnatum 29
  L. obtectum 33
  L. prominens 36
  L. pseudomacrostomum 33, 47
  L. quadrinucleatum 46
  L. quadrinucleatum var. triseptatum 46
  L. scrophulariae 41
  L. sieversiae 42
  L. spiraeae 43
  L. spiraeae var. adultum 43
  L. triseptata 46

  L. triseptata var. minimum 47
  L. triseptata var. nigrificans 47
  L. turritum 47
  L. viridiarum 29
Lophiotrema parasitica 34
  L. praemorsum 41, 43
  L. scrophulariae 41
  L. spiraeae 43
  L. vestita 48
Lophiotricha viridicoma 49
Lophodermina exarida 21
Lophodermium exaridum 21
Mamianiella coryli var. spiralis 17
Massaria inquinans 49
  M. xanthoxyli 49
Massariella bufonia 9
  M. curreyi var. americana p. 17
  M. xanthoxyli 49
Massarina alnea 7
  M. gloeospora 9
  M. myricae 31
Massariosphaeria rubelloides 29
Melanconiella acrocystis 6
  M. meschuttii 32
  M. nigrospora 32
Melanconis acrocystis 6
  M. alni var. marginalis 30
  M. chrysostroma 22
  M. elliptica 20
  M. marginalis 29
  M. meschuttii 32
  M. nigrospora 32
Melanomma coniothyrium 30
  M. rhododendri 26
Melanopsamma pomiformis 21
  M. recessa 39
Melanospora sphaerophila 43
Meliola balsamicola 10, 32
Melogramma effusum 19
  M. superficialis 45
Metameris iaponica 34
  M. osmundae 34
Metasphaeria humulina 24
  M. myricae 31
  M. nuda 32
  M. semen 41
  M. staphylina 43
  M. taxicola 45
Microdiplodia 21
Microsphaera abbreviata 6
  M. alni 6
  M. alni var. alni 13
  M. alphitoides 6
  M. ceanothi 13
  M. densissima 18
  M. diffusa 19
  M. erineophila 20
  M. euphorbiae 20
  M. extensa 21
  M. friesii var. castaneae 23
  M. friesii var. syringae 23
  M. friesii var. vaccinii 23
  M. nemopanthis 32
  M. penicillata 6, 32
  M. penicillata var. alni 35
  M. penicillata var. penicillata 13, 18, 20, 23, 35, 37
  M. penicillata var. vaccinii 23
  M. pulchra 37
  M. vaccinii 48
  M. penicillata var. extensa 21
Microthelia applanata 35
  M. atrogrisea 9
  M. parnassiae 34
Mycosphaerella alnicola 7
  M. arbuticola 8
  M. arbutifoliae 8
  M. chimaphilae 13
  M. colorata 15
  M. conigena 16
  M. cypripedii 17
  M. depressa 18
  M. effigurata 22
  M. impatientis 25
  M. indistincta 25
  M. lycopodii 28
  M. orbicularis 33
  M. peckii 16
  M. pontederiae 36
  M. pteridis 25
  M. pyrolae 13
  M. rubina 40
  M. sphaerellula 43
  M. spleniata 43
  M. thalictri 41
  M. tsugae 16
Myriangium asterinosporum 45
  M. duriaei 36
  M. superficialis 45
Mytilinidion thujarum 46
Navicella magnata 29
  N. prominens 37
Nectria apocyni 8
  N. atrofusca 41
  N. balsamea 10
  N. celastri 13
  N. cinnabarina 13
  N. mycetophila 31

Nectriella mycetophila 31
Neodeightonia ramulicola 39
Neofracchiaea callista 12
Neopeckia coulteri 17
Niesslia pulchriseta 38
Nitschkia callista 12
Nodulosphaeria modesta 34
Oedemium didymum 35
Ophiobolus drechsleri 23
  O. fulgidus 23
  O. subolivaceus 45
Ophiovalsa caryae 13
  O. cinctula 14
  O. corylina 45
  O. femoralis 22
  O. tomentella 46
  O. trichispora 46
Otthia alnea 7
  O. seriata 41
Otthiella seriata 41
Patellaria fenestrata 22
  P. fusispora 23
  P. hamamelidis 24
  P. indigotica 25
  P. leptosperma 27
  P. pusilla 38
Peckiella banningiae 10
  P. camphorati 12
  P. hymenii 10, 24
  P. hymenioides 24
  P. polyporinus 36
  P. transformans 46
  P. xylophila 49
Periconia sphaerophila 43
Phaeangiella deformata 18
Phaeocryptopus nudus 32
Phaeosphaeria clavispora 15
  P. corallorhizae 16
  P. fuckelii 29, 41
  P. marciensis 29
  P. typhicola 14
Phaeostoma sphaerophila 43
Phaeotrichosphaeria caesariata 12
Philocopra canina 13
Phomatospora leptasca 27
Phragmodiaporthe caryae 13
  P. tiliacea 10
Phyllachora dasylirii 18
  P. episphaeria 20
  P. kalmiae 26
Phyllosticta 45
Physalospora ceanothina 13
  P. megastoma 30
Plagiostoma campylostylum 31
  P. campylostylum var. mirabilis 31
  P. devexum 19
Platychora alni 7
Platyspora permunda 18
Pleomassaria monosperma 31
  P. siparia 31
Pleospora calvescens 21
  P. comata 22
  P. lichenalis 27
  P. magnifica 29
  P. njequsensis 29
  P. rubicunda var. americana 29
  P. shepherdiae 41
  P. tragacanthae 22
Pleurage canina 13
  P. valsoides 48
Podonectria coccicola 14
Podosordaria pedunculata 29
Podosphaera biuncinata 11
Podospora appendiculata 21, 48
Polymorphia citri 14
Polystigma astragali 30
Poronia macrospora 29
Prosthecium acrocystis 6
Protoventuria curviseta 17
  P. quercina 33
Pseudotrichia mutabilis 34, 48, 49
  P. viridicoma 49
Pseudovalsa lanciformis 20
  P. sambucina 40
  P. xanthoxyli 49
Pyrenobotrys compacta 15
  P. pulchella 37
Pyrenophora depressa 18
  P. fenestrata 22
Rhaphidospora fulgida 23
Rhopographus clavisporum 14
Rhynchostoma altipeta 8
  R. rubefaciens 40
  R. rubrocinctum 40
Rhytidhysterium prosopidis 37
Rhytidhysteron rufulum 17, 37
Rhytisma sparsum 42
Romellia cornina 17
Rosellinia hirtissima 24
  R. linderae 28
  R. mutans 31
  R. subiculata 31
  R. trichota 24
Ryparobius cookei 13
Saccothecium taxicolum 45
Schizothecium aloides 48
Scirrhia conigena 16
  S. osmundae 33
Scirrhophragma osmundae 33
Scirrhophragmia regalis 34

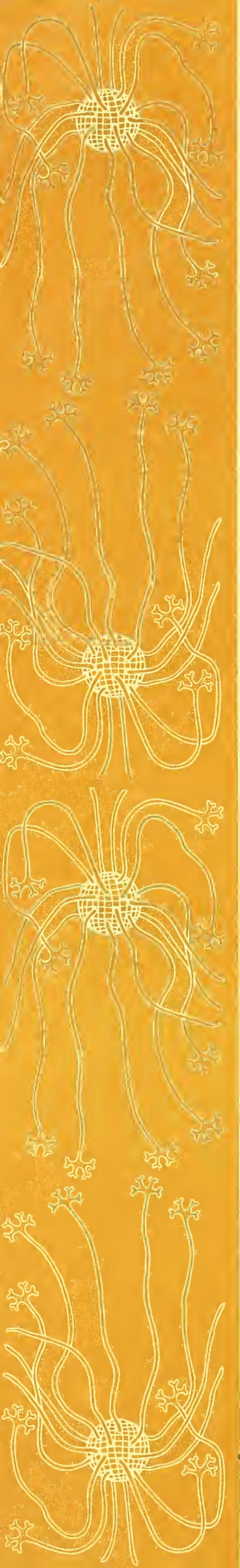
Scoleconectria balsamea 10
Scopinella sphaerophila 43
Sepedonium chrysospermum 11
Shepherdia canadensis 42
Sordaria valsoides 48
Sphaerella alnicola 7
  S. arbuticola 8
  S. arbutifoliae 8
  S. chimaphilae 13
  S. chimaphilina 13
  S. colorata 15
  S. conicola 16
  S. conigena 15, 16
  S. cypripedii 17
  S. depressa 18
  S. fraxinea 22
  S. gaultheriae 23
  S. impatientis 25
  S. indistincta 25
  S. lycopodii 28
  S. megastoma 30
  S. nigrita 43
  S. orbicularis 33
  S. paludosa 36
  S. peckii 16
  S. pontederiae 36
  S. rubina 40
  S. saccharoides 40
  S. septorioides 41
  S. spleniata 43
  S. tsugae 16
Sphaeria albidostoma 7
  S. altipeta 8
  S. amphicornis 21
  S. arceuthobii 9
  S. caesariata 12
  S. callista 12
  S. canina 12
  S. ceanothina 13
  S. celastri 13
  S. clavariina 14
  S. clavulata 15
  S. clintonii 15
  S. coniothyrium 30
  S. coryli var. spiralis 17
  S. coulteri 17
  S. curvicolla 17
  S. desmodii 18
  S. eccentrica 19
  S. exercitalis 21
  S. exigua 21
  S. eximia 21
  S. fulgida 23
  S. glaeospora 9
  S. hendersoniae 30
  S. hirtissima 24
  S. humulina 24
  S. interstitialis 26
  S. leonina 27
  S. lichenalis 27
  S. lilacina 48
  S. marciensis 29
  S. melantera 30
  S. monosperma 31
  S. mutans 31
  S. onosmodina 33
  S. parnassiae 34
  S. petiolophila 35
  S. phaeostromoides 35
  S. phileura 35
  S. pulchriseta 37
  S. racemula 38
  S. ramulicola 38
  S. recessa 39
  S. rhodospila 19
  S. rubefaciens 39
  S. salebrosa 40
  S. scapophila 41
  S. scopula 41
  S. semen 41
  S. smilacinina 42
  S. sorghophila 42
  S. sphaerellula 43
  S. squalidula 43
  S. staphylina 43
  S. subconica 44
  S. subcorticalis 44
  S. subdenudata 44
  S. taxicola 45
  S. thujina 46
  S. valsoides 48
  S. viridella 48
  S. viridicoma 48
Sphaerodothis pringlei 36
Sphaerotheca humuli 37
  S. mors-uvae 34
  S. pannosa var. ribis 34
  S. pruinosa 37
Sphaerulina sambucina 40
  S. taxicola 45
Splanchnonema ampullaceum 17
Sporidesmium socium 12
Sporocybe sphaerophila 43
Sporormia leptosphaerioides 42
Sporormiella sorghophila 42
Stigmatea conferta 15
  S. pulchella 37
Strickera interstitialis 26

Teichospora aridophila 9
  T. interstitialis 26
  T. obducens 9
  T. trabicola 9
  T. xerophila 9
Thaxteria fusca 35
Thyridaria incrustans 41
  T. sambucina 41
Thyronectria xanthoxyli 49
Torrubia clavulata 15
  T. superficialis 45
Trematosphaeria pertusa 39
  T. salebrosa 40
Triblidium fenestratum 22
  T. platascum 36
Trichometasphaeria gloeospora 9
Trichosphaeria pulchriseta 37
  T. subcorticalis 44
Trichothyrina tracyi 46
Tryblidaria fenestrata 22
Tubeufia clintonii 15
  T. scopula 41
Uncinula ampelopsidis 8
  U. bicornis 14
  U. circinata 14
  U. clintonii 15
  U. flexuosa 22
  U. macrospora 29
  U. necator 8
  U. parvula 34
Uncinuliella flexuosa 22
Valsa acerina 6, 7
  V. acrocystis 6
  V. albocincta 6, 7
  V. alni 7
  V. ambiens 27
  V. americana 7
  V. bicincta 11
  V. brevis 11
  V. ceratosperma 40
  V. cinctula 14
  V. cornina 16
  V. exudans 21
  V. femoralis 22
  V. fraxinicola 23
  V. fraxinina 23
  V. grisea 23, 24
  V. impulsa 25
  V. innumerabilis 25
  V. leptasca 27
  V. leucostomoides 27
  V. linderae 28
  V. melanodiscus 7, 47
  V. mucronata 31
  V. obscura 32
  V. opulifoliae 33
  V. oxyspora 34
  V. paucispora 35
  V. prunicola 37
  V. pulviniceps 38
  V. rubi 40
  V. sambucina 40
  V. subclypeata 44
  V. thujae 45
  V. tomentella 46
  V. trichispora 46
  V. truncata 47
  V. tumidula 47
  V. woolworthi 49
  V. xanthoxyli 49
Valsaria angulare 8
  V. exasperans 12
  V. moroides 31
  V. niesslii 32
  V. nigrospora 32
  V. purpurea 38
  V. quadrata 11
Valsella acerina 27
  V. adherens var. americana 6
  V. laschii var. acerina 26
Venturia cassandrae 13
  V. clintonii 15
  V. compacta 15
  V. curviseta 17
  V. ditricha 29
  V. kalmiae 26
  V. maculans 29
  V. orbicula 33
  V. orbicularis 33
  V. pulchella 37
  V. systema-solare 15
Wallrothiella arceuthobii 9
  W. squalidula 43
Wettsteinina sieversiae 42
Winterella cinctula 14
  W. femoralis 22
Xylaria acuta 6
  X. corniformis 16
  X. corniformis var. irregularis 16
  X. digitata var. americana 19
  X. digitata var. tenuis 19
  X. grandis 24
  X. hypoxylon 6
  X. polymorpha 24
  X. polymorpha var. combinans 36
Zignoella exigua 21
  Z. humulina 24
Zukalia balsamicola 10

Index to Host Taxa

Abies balsamea 10, 11, 32
Acer 15, 23, 35, 41, 49
  A. glabrum 6
  A. pensylvanicum 43
  A. rubrum 14, 24, 39
  A. saccharinum 19, 27
  A. saccharum 26, 27, 35, 39
  A. spicatum 6, 7, 12, 14, 26, 35
Aescululs glabra 20
Aesculus hippocastanum 7, 22
Agiosporina morbosa 43
Alnus 7, 22, 31, 34, 35, 47
  A. incana 22, 31, 45
  A. rubra 11
  A. rugosa 7
  A. viridis 7, 30
Ambrosia trifida 23
Amelanchier canadensis 47
Ampelopsis quinquefolia 8
Apocynum cannabinum 8
Arabis 18
Aralia racemosa 7
Arbutus menziesii 8
Arceuthobium pusillum 9
Asparagus 9
Astragalus bisulcatus 30
beech 20, 38, see Fagus
Bertia moriformis 34
Betula 27, 31, 36
  B. lenta 6
  B. lutea 11, 31, 32
  B. populifolia 6, 19, 20, 29, 46
birch 27, see Betula
Borreria micrantha 46
Cantharellus cibarius 46
Carpinus caroliniana 12, 22, 44
Carya alba 13
Castanea 24, 48
  C. dentata 14
  C. vesca 23
Ceanothus americanus 13
Celastrus scandens 13
Celtis occidentalis 34
Cephalanthus occidentalis 37
Chamaedaphne (Cassandra) calyculata 13, 37
Chenopodium album 21
Chimaphila umbellata 13
Citrus aurantium 14
Clavaria cristata 14
Corallorhiza multiflora 16
Cornus 26
  C. alternifolia 12, 37
  C. paniculata 16
  C. rugosa 15
Corylus 8, 45
  C. americana 17
  C. californica 17
  C. cornuta 17
  C. rostrata 17
Crataegus 47
Cyathus striatus 27
Cypripedium insigne 18
Cyrilla 20
Dalibarda repens 18
Dasylirion wheeleri 18
Desmodium 19
  D. canadense 19
Diatrype stigma 20
Diervilla trifida 39
Epigaea repens 48
Epilobium angustifolium 38
Euonymus 41
Euphorbia hypericifolia 20
Fagus 20, 34, 38, 48, 49
  F. ferruginea 30
Fraxinus 22, 23, 24, 38, 46
  F. americana 23
  F. nigra 45
  F. sambucifolia 15
Gaylussacia baccata 48
Geum rossii 42
Hamamelis virginiana 11, 24
Hicoria 48
hickory 30, see Carya
Humulus lupulus 24
Hypoxylon morsei 34
Ilex verticillata 15
Impatiens fulva 25
Indian corn 30
Juglans cinerea 11, 47
Juniperus 18
  J. virginiana 9
Kalmia angustifolia 15, 21, 26
  K. glauca 26
Lactarius 10, 38
  L. camphoratus 12
  L. uvidus 24
  L. vellereus 24
Lactuca 18, 44
Ledum groenlandicum 27

Lilium longiflorum 16
Lindera benzoin 28
Lycopodium annotinum 29
  L. clavatum 28
  L. selago 29
Lyonia ligustrina 28
Lythrum alatum 29
Magnolia acuminata 11
maple 49, see Acer
Melilotus alba 48
Mentha piperata 45
Mulgedium 44, see Lactuca
Myrica gale 26, 31
Nemopanthus canadensis 32
  N. mucronatus 17, 34
Onosmodium carolinianum 33
Osmunda 34
Panicum miliaceum 32
Parnassia caroliniana 34
Phlox 29
Phragmites communis 14
Physocarpus opulifolius 32, 33
Phytolacca decandra 48
Picea mariana 9
Pinus 17, 29
Polygonum 19
  P. articulatum 17
Polyporus chioneus 10
  P. versicolor 36
Pontederia cordata 36
Populus 20, 22, 47
  P. deltoides 39
  P. grandidentata 33
  P. tremuloides 48
Prosopis glandulosa 47
  P. juliflora 37
Prunus 26, 43
  P. pensylvanica 17, 37, 47
Pteridium aquilinum 25
Pyrus 46
  P. (Aronia) melanocarpa 8
  P. americana 25
  P. arbutifolia 8
Quercus 6, 11, 18, 24, 44, 46, 49
  Q. alba 9
  Q. bicolor 43
  Q. montana 33
  Q. rubra 21
  Q. tinctoria 38
Rhododendron maximum 44
Rhus glabra 37
  R. toxicodendron 42
  R. typhina 26, 27
Ribes cynosbati 34
Rubus 40
  R. strigosus 30, 33
  R. villosus 40
Sabal palmetto 43
Saccharum officinarum 40
Salix 31, 47
Sambucus callicarpa 12
  S. canadensis 38, 40, 41
Sarracenia purpurea 41
Sassafras officinale 44
Scrophularia nodosa 41
Sieversia turbinata 42
Smilacina stellata 42
Sorbus americana 25, 41, 45
Spermococe parviflora 46
Spiraea opulifolia 43
  S. opulifolius 43
Staphylea trifoliata 43
Syringa vulgaris 23
Taxus canadensis 45
Thalictrum 44
  T. dioicum 41
  T. polygamum 45
Thuia occidentalis 16
Thuja occidentalis 46
Tilia americana 8, 10, 15, 17, 35, 38
Tsuga canadensis 16
Typha latifolia 47
Ulmus 29
  U. americana 25, 28, 38
Vaccinium 40
  V. corymbosum 23
  V. macrocarpon 15
  V. pennsylvanicum 48
  V. vacillans 48
Vitis 49
Xanthoxylum americanum 33, 49
Yucca macrocarpa 36



New York State Education Department
Albany, New York 12234

NON PROFIT ORG.
U. S. POSTAGE
PAID
Albany, N.Y.
Permit No. 293

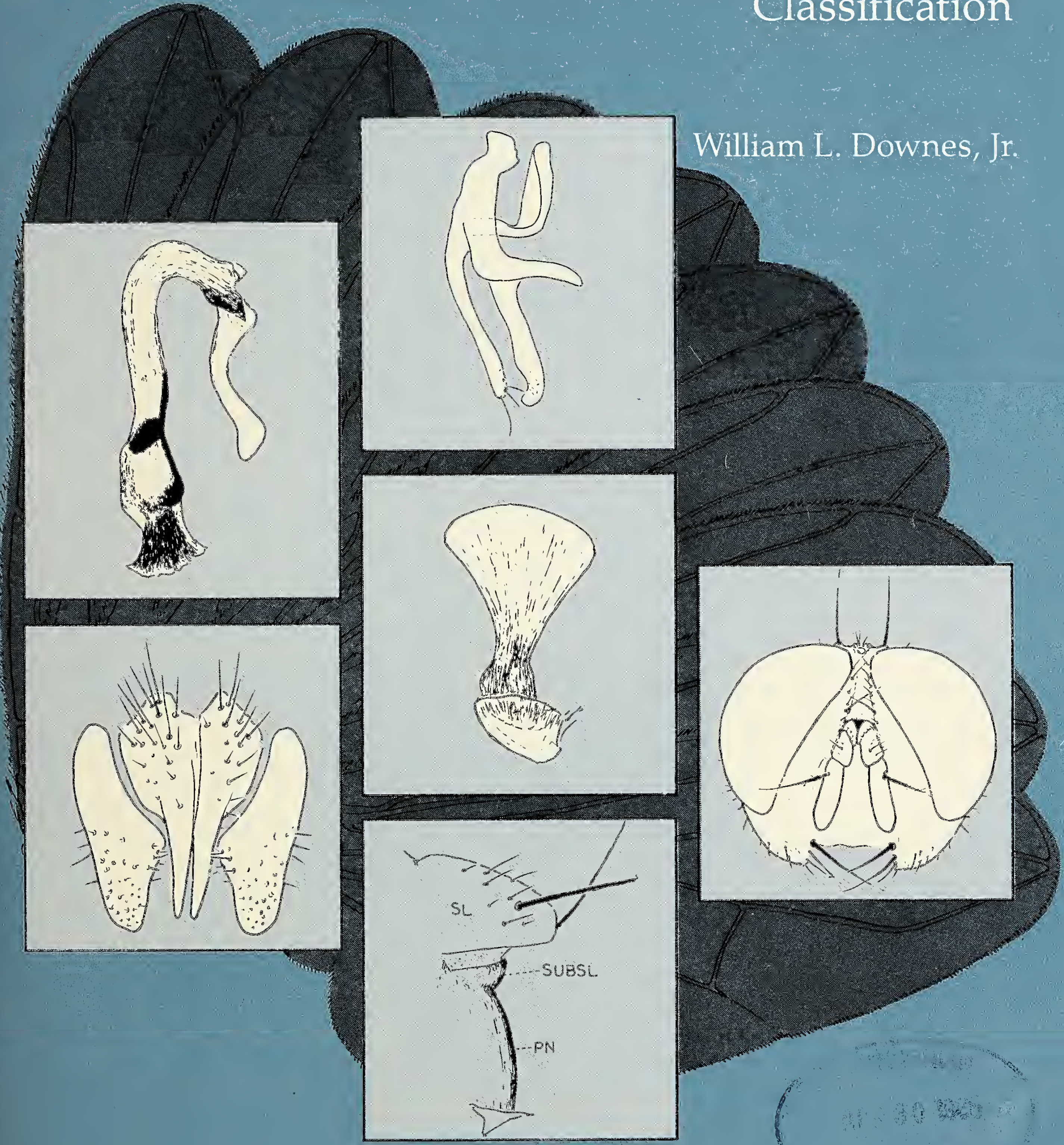
85-7325
58600

Bulletin 459
ISSN 0278-3355
ISBN 1-55557-005-4

Q
11
N82X
NH

E NEARCTIC *MELANOMYA* AND RELATIVES
(Diptera: Calliphoridae)
A Problem in Calyptrate Classification

William L. Downes, Jr.



The University of the State of New York • The State Education Department
Albany, New York 12230

The Nearctic *Melanomya* and Relatives (Diptera: Calliphoridae), a Problem in Calyptrate Classification

William L. Downes, Jr.
Department of Entomology
Michigan State University
East Lansing, Michigan 48933

1986
Bulletin No. 460
New York State Museum
ISSN 0278-3355
ISBN 1-55557-000-3

The State Education Department does not discriminate on the basis of age, color, religion, creed, disability, marital status, veteran status, national origin, race, or sex in the educational programs and activities which it operates. Inquiries concerning this policy of equal opportunity and affirmative action should be referred to the Department's Affirmative Action Officer, Education Building, Albany, NY 12234. Phone (518) 473-1265.

The University of the State of New York
THE STATE EDUCATION DEPARTMENT
Albany, New York 12230

150th ANNIVERSARY
1836 1986
NEW YORK STATE MUSEUM
BIOLOGICAL SURVEY

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of The University *(with years when terms expire)*

1987	MARTIN C. BARELL, Chancellor, B.A., I.A., LL.B., LL.D.	Muttontown
1987	R. CARLOS CARBALLADA, Vice Chancellor, B.S., L.H.D., D.Sc.	Rochester
1986	KENNETH B. CLARK, A.B., M.S., Ph.D., LL.D., L.H.D., D.Sc	Hastings on Hudson
1988	WILLARD A. GENRICH, LL.B., L.H.D., LL.D., Litt.D., D.C.S., D.C.L., Sc.D.	Buffalo
1989	EMLYN I. GRIFFITH, A.B., J.D.	Rome
1991	JORGE L. BATISTA, B.A., J.D., LL.D.	Bronx
1986	LAURA BRADLEY CHODOS, B.A., M.A.	Vischer Ferry
1991	LOUISE P. MATTEONI, B.A., M.A., Ph.D.	Bayside
1988	J. EDWARD MEYER, B.A., LL.B., L.H.D.	Chappaqua
1988	FLOYD S. LINTON, A.B., M.A., M.P.A., D.C.L., LL.D.	Miller Place
1988	SALVATORE J. SCLAFANI, B.S., M.D.	Staten Island
1989	MIMI LIEBER, B.A., M.A.	Manhattan
1992	SHIRLEY C. BROWN, B.A., M.A., Ph.D.	Albany
1990	NORMA GLUCK, B.A., M.S.W., LL.D.	Manhattan
1990	THOMAS R. FREY, A.B., LL.B.	Rochester
1990	JAMES W. McCABE, Sr., A.B., M.A.	Johnson City

President of The University and Commissioner of Education
Gordon M. Ambach

Executive Deputy Commissioner of Education
Robert J. Maurer

Deputy Commissioner for Cultural Education
Carole F. Huxley

Assistant Commissioner for the State Museum
Martin E. Sullivan

Director, State Science Service
Richard H. Monheimer

Chief Scientist, Biological Survey
Norton G. Miller

ABSTRACT

Melanomya, Glutoxys, and *Pseudopsodexia* comprise a small group of genera whose systematic position has never been clearly established. Relationships of the New World species with the European fauna are indicated, and reasons are given for assigning the genera to the Calliphoridae. The group is revised for the Nearctic Region. *Angioneurilla* and *Eggisops* are synonymized with *Melanomya* (NEW SYNONYMY). *Melanomya (Opsodexia) nox,* new species, is described from Ohio, Iowa and Tennessee. Four species, and probably a fifth, have been reared as parasites of snails.

ACKNOWLEDGMENTS

A number of individuals provided various kinds of assistance during the course of this study. Discussions with P. H. Arnaud, Jr., R. L. Fischer, W. E. LaBerge, J. L. Laffoon (deceased), C. W. Sabrosky, A. Stone, J. C. Schaffner, and J. R. Wick materially improved some of the ideas presented here. H. J. Reinhard (deceased) provided help and facilities for examining his personal collection at Texas A. & M. University and furnished information on the holotypes of *Opelousia mitis* and *Opelodexia artata*. C. O. Berg, H. R. Dodge (deceased), B. A. Foote, J. L. Laffoon, C. W. Sabrosky, J. C. Schaffner and R. E. Widdows generously made material available from their personal collections.

I am further indebted to the following individuals who either provided working space at, or arranged for loans from, the institutions given after their names: C. H. Curran (deceased), American Museum of Natural History; A. G. Humes, Boston University; J. G. Chillcott (deceased), G. E. Shewell and J. R. Vockeroth, Canadian National Collection; G. Wallace, Carnegie Museum; H. Dietrich, Cornell University; Howard V. Weems, Jr., Florida State Collection of Arthropods; H. H. Ross (deceased), Illinois Natural History Survey; D. D. Millspaugh, Iowa Wesleyan College; W. E. LaBerge, University of Kansas; R. L. Fischer, Michigan State University; W. L. Brown, Jr., Museum of Comparative Zoology, Harvard University; H. J. Grant, Jr., Academy of Natural Sciences of Philadelphia; J. F. Gates Clarke and C. W. Sabrosky, United States National Museum.

The information presented here is largely an amplified portion of my doctoral thesis (Downes, 1958), which was completed under the direction of H. M. Harris and J. L. Laffoon at Iowa State University.

CONTENTS

INTRODUCTION 1
TAXONOMY OF THE *MELANOMYA* GROUP 3
  Key to the New World Genera 3
GLUTOXYS 3
    elegans 4
MELANOMYA 4
  Key to Subgenera and Species 5
  (*MELANOMYA*) 6
    nana 6
  (*EGGISOPS*) 7
    pecchiolii 7
  (*ANGIONEURA*) 7
    cyrtoneurina 8
    obscura 8
    flavescens 9
    abdominalis 10
    ordinaria 10
    mitis 11
  (*OPSODEXIA*) 11
    bicolor 11
    flavipennis 12
    grisea 12
    nox 13
PSEUDOPSODEXIA 13
  A Key to Species 14
    cruciata 14
    horebana 14
SYSTEMATIC POSITION 14
  Primitive Tachinoid, Parallelisms 15
  Composition of the Rhinophoridae 17
  Systematic Position of *Melanomya* 18
  Composition of *Melanomya* 19
LITERATURE CITED 21
PLATES 23

INTRODUCTION

The flies treated here are rather small tachinoid flies varying in ground color from black with a brown tinge to a weakly infuscated straw yellow. Many, and possibly all of the species parasitize snails. They do not resemble typical carrion-breeding Calliphoridae, and for this reason have seldom been associated with them in the past. They are superficially closer in appearance to certain nondescript Anthomyiidae, and it is not unusual to find specimens of the group among anthomyiids in collections.

Most members of this group show many primitive characters, and some species have a large number of them. Like other primitive Tachinoidea, these species are unusually variable, especially in chaetotaxy, which creates problems in the use of keys. Single key characters are not always reliable. Their relict character also makes it difficult to recognize their affinities with other tachinoids. Almost without exception, they exhibit the primitive alternatives to the defining character-states of the major tachinoid families. As a result, they have never been assigned consistently to any tachinoid family, but have been scattered variously among the Calliphoridae, Rhinophoridae, Sarcophagidae, and Tachinidae. However, the primitive features of these flies have provided some valuable clues for understanding tachinoid evolution.

For many years the taxonomy of the *Melanomya* species developed independently in North America and Europe. Most of it consisted of brief accounts, and the differing nomenclatures and brief treatments provided few clues to basic similarities. As a consequence, the relationships between the Old and New World species went unrecognized. However, *Melanomya* is common to both continents, and *M. ordinaria* (West) is so close to the European *M. acerba* (Meigen) that they may be the same species (judging from Séguy's (1941) figure of *M. acerba* – I have not seen the latter). The far northern records of *M. ordinaria* suggest that it may have a Holarctic distribution.

A few relationships between the European and American forms were indicated in the *Catalog of the Diptera of America North of Mexico* (Downes, 1965), but space limitations precluded any explanation. This paper has been written to explain the decisions made at that time, and to provide a fuller treatment of the Nearctic species. It is also an attempt to reduce the confusion that has surrounded the classification of *Melanomya* and other primitive calyptrates.

The inclusion of information about European species is necessary to settle some problems of nomenclature. The intent is to circumvent future nomenclatorial changes by including pertinent data about species on which older generic names have been based. So far as I can tell, other generic names for Old World species will be junior synonyms of those employed in this study should the Old World species prove congeneric with Nearctic species.

The primary focus here is on the Nearctic fauna. For this reason, no attempt has been made to present complete accounts of the European species. I have not seen and have not obtained information on European type-specimens or on several genera and species which are obviously or possibly related to Nearctic species, nor have I attempted to survey the European literature. Representatives of several Old World genera and species in the United States National Museum were examined in 1956, including series of *M. nana* (Meigen) and *M. pecchiolii* (Rondani), but I did not record the label data. It is therefore not possible to cite the material examined for those species.

If their frequency in collections gives an accurate picture, members of the genus are seldom collected. This is no doubt due in part to their small size and nondescript appearance, but the populations also appear to be rather localized. Most of the Nearctic species seem to occur in relict populations confined to eastern North America, although *M. ordinaria* has a northern distribution that extends into western North America. The majority of the specimens collected during the early stages of this study were found in a deep, humid ravine along the Des Moines River near Boone, Iowa (they were all *M. obscura* (Townsend). I have been unable to find *Melanomya* in level territory in Iowa, Missouri, Illinois, or Michigan after much searching, even in woods. Perhaps this reflects a special ravine habitat of their snail hosts; it might explain their greater frequency in the mountainous areas of eastern North America.

Most of the Iowa males of *Melanomya obscura* were found taking stations three to five feet above ground level on the upper sides of leaves or twigs of scattered bushes in fairly dense woods, but in small patches of direct sunlight. Occasionally they could be induced to fly out after small bits of material thrown appropriately past their station. They showed some discrimination, and pursued small insects passing by much more readily than inert objects thrown past them. How they distinguished between the two kinds of objects is not known; it is more likely a matter of speed, flight path, or some such factor rather than an accurate form perception. Many larger and faster calyptrates, when tested in a similar fashion, appear to be less discriminating.

The station-taking habit renders males more conspicuous than females, which would account for the predominance of the former in collections. Since the fronts of the males are significantly narrower than those of the females in the Nearctic species, the station-taking habit is probably common to all of them. The correlation is actually between station-taking behavior and eyes enlarged dorsally, apparently for better vision for detecting females at greater distances. The larger eyes take up more of the dorsal surface of the head, which results in a narrower space between them. A similar narrowing of the space between the eyes occurs in *Amobia* (Sarcophagidae), most conspicuously in the females which trail wasps. The males of the Palearctic *M. cyrtoneurina* (Zetterstedt), however, have broad fronts—that is, their eyes are comparatively smaller.

The morphological terminology of the new *Manual of Nearctic Diptera* (McAlpine *et al.,* 1981) has been adopted for the discussions and descriptions that follow. Descriptions and figures for nearly all the terms can be found in that work. Many parts are also labelled in the first few figures of the plates given here. However, I have continued to use "metasternum" for the transverse bridge in front of the hind coxae, even though this structure is not a true metasternum. It is convenient, and no other term has come into use in the taxonomic literature. An older taxonomic term, "first genital tergum," has also been substituted for the structure called the "syntergosternum 7+8" of McAlpine *et al.* (1981), since the identity of this part does not seem to have been adequately established yet.

The terminology for the family and superfamily classification of the calyptrate Diptera has likewise been borrowed from the *Manual,* and is to be presumed for all discussions in this paper, except that I exclude the bot flies (as Oestroidea) from the Tachinoidea.

In the descriptions of species the "length of the aedeagus" means the approximate length the aedeagus would be if it were straightened out, but excluding the length of the epiphallus (spine). The basiphallus is the pigmented, basal portion of the aedeagus down to the clear area on the anterior surface near the midpoint of the aedeagus. The main longitudinal axis of the aedeagus is the axis of the shaft distal to the basiphallus when the latter is strongly curved as it is in subgenus *Angioneura.*

In the figures all lateral views have been drawn with the flies facing left on the plate. The male genitalic parts have been drawn as if they were in place in spread genitalia, that is, with the tips of the aedeagi, gonopods, parameres, cerci, and surstyli pointed ventrally.

There is no one scale for all figures, although all genitalic figures for a species are drawn to the same scale. The vertical line (0. 25 mm) beside an aedeagus thus applies to all figures of the genitalic parts of that species. Figures 54 to 66 and 72 to 82 are enlarged to approximately 2. 2X the scale for *Melanomya mitis* (Reinhard) (Fig. 8). Nongenitalic figures were drawn to whatever scale was convenient, which is not given except for the head and wing figures.

Label information on holotypes has been given as it occurs on the labels, although collectors' names have been enclosed in parentheses. Label information otherwise has been translated into a standard format, except when the information is somewhat cryptic. In such cases the label information is enclosed in quotation marks, or it is commented on in a following paragraph.

A question mark before an author's name in the synonymies of the species indicates that the material on which the reference is based has not been seen, and it is possible that the identification is incorrect.

Names for the contiguous United States have been abbreviated according to the United States Postal Service system. Other territorial names have been spelled out.

TAXONOMY OF THE *MELANOMYA* GROUP

Differentiating characters:

Members of the *Melanomya* group are distinguished from other calyptrates by the following set of characters:

Head: Facial plate without keel or bridge separating the antennal sockets (Fig. 1, cf. Fig. 22), first antennal segments contiguous; intrapostocular cilia absent.

Thorax: Coxopleural streak absent; subscutellum small but distinct (Fig. 3), occasionally absent (missing in *Melanomya nana* (Meigen), *Pseudopsodexia* and *Glutoxys);* infrasquamal setulae present; katatergite without long hairs; bend of vein M shallow, ending in the costa at or a little behind the extreme wing tip (Fig. 7); apical anterodorsal bristle of foretibia strongly differentiated, larger than dorsal apical (except for occasional specimens of *Melanomya nana* in which the anterodorsal bristle is slightly smaller); a preapical anterior bristle of midfemur differentiated (Fig. 21), rarely absent in some specimens of *Melanomya bicolor* (Coquillett); hind coxa without setae on posterior surface.

Additional characters:

Head: Eye bare; front of male considerably narrowed dorsally by the approximation of the eyes (Fig. 1) (except in the European *M. cyrtoneurina);* frontals not extending as far anteriorly as middle of second antennal segment (Fig. 1), seldom attaining base of second segment; facial ridge without bristles above vibrissa, with small setae only near the vibrissa; third antennal segment covered with fine, whitish, hair-like units, which are usually longer that the width of the thickened portion of the arista; arista bare to plumose; haustellum short, prementum pollinose; labellum proportionately large, fleshy.

Thorax: Postsutural dorsocentrals, 3; notopleurals, 2, the anterior bristle distinctly larger than the posterior bristle; katatergite without setae; lower calypter without dorsal hairs; wings with a brownish or yellowish tinge; dorsal and ventral surfaces of wing membrane completely covered with microtrichiae; third section of costa with ventral setulae; R1 asetulate with rare exceptions.

Abdomen: Alphasetae present on extreme anterior edges of abdominal sterna 2 to 5 (Figs. 19, 20); second tergum (morphological) without median marginals.

Male: Aedeagus with a basal, posterior spine, the epiphallus (Fig. 8), and short paraphallic lobes (Figs. 8, 9, 39, and others), the latter hook-like and appressed to shaft of the aedeagus; sternites of segment ten large and nearly contiguous medially (Figs. 40, 76), or a single tenth sternum present; surstylus nearly as large as, or larger than, cercus (Figs. 11, 15, etc); fifth sternum U- or V-cleft on posterior margin.

Two Neotropical genera, *Glutoxys* and *Pseudopsodexia,* are included in the following revision for the sake of completeness. They include the only other New World species I know of that are obvious relatives of *Melanomya.*

Key to the New World Genera of the *MELANOMYA* Group

1. Posterior surface of head with some whitish hairs; mesoanepisternum with a single bristle differentiated from the surrounding setulae on the anterodorsal region and directed anterodorsally (Fig. 25) 2
   Posterior surface of head without whitish hairs; mesoanepisternum with setulae of nearly uniform size on anterodorsal region (Fig. 6) . . . . *MELANOMYA*
2. Dorsal surface of scutellum without setae, or at most a setula or two present near edge; hind tibia with but one anterodorsal and one posterodorsal bristle (excluding apicals) . . . .*GLUTOXYS*
   Dorsal surface of scutellum with usual vestiture of several to many setulae; hind tibia with two bristles in both anterodorsal and posterodorsal rows . . . . *PSEUDOPSODEXIA*

Genus *GLUTOXYS* Aldrich

Glutoxys Aldrich, 1929: 2 (type-species: Glutoxys elegans Aldrich, by orig. desig.); Townsend, 1935b: 260; 1938: 222-223; Lopes, 1973: 277.

This genus is defined by the characters of the group plus the characters given in the preceding key and the following: parafacialium without setae or with one or two setulae near the dorsal limit; arista plumose; third antennal segment with a coat of fine whitish pile, pile units shorter than the thickened portion of the arista; prosternum and dorsal proepisternum without setae; one presutural acrostichal; a single strong bristle differentiated and directed anterodorsally near the anterodorsal corner of the mesoanepisternum (Fig. 25); knob of halter pale colored.

Lopes (1969) assigned this difficult-to-place genus to the Sarcophagidae (Sarcophagini), although he later placed it in the Calliphoridae (Lopes, 1973). The aedeagus (Fig. 18) bears a vague resemblance to those of certain Sarcophagidae of the tribe Miltogrammini, and the preabdominal sterna lack evident alphasetae, which are characteristically absent in the Sarcophagidae. However, neither of these two characters is definitive. Some Calliphoridae lack alphasetae like the Sarcophagidae. *Glutoxys* individuals are quite small, as are those of the Miltogrammini to which they might be compared, and many of the similarities seem to be secondary simplifications resulting from the reduced body size.

The difficulties of assigning *Glutoxys* to the Sarcophagidae become clearer if we attempt to place it more precisely within the family. It is decidedly aberrant among the Miltogrammini in having long, fine infrasquamal setulae, a first antennal segment not flush with the lunule, no coxopleural streak, a plumose arista, and both preapical dorsal and posterodorsal bristles present on the hind femur. It also cannot be affiliated with any known member of the Miltogrammini quite apart from the deviations in the above characters.

The distinct sixth tergum in the male separates the genus from the Paramacronychiini (Sarcophagidae). The surstylus is also free, not fused with the second genital tergum, and there are no secondary meral hairs among the bristles of the usual meral row, such as are present in genuine Paramacronychiini. The Sarcophaginae almost always have hairs on the posterior surface of the hind coxa as well as four notopleurals. *Glutoxys* does not have hairs on the posterior surface of the hind coxa; it has only two notopleurals, and the male genitalia do not resemble those of any Sarcophaginae I have seen. The genus differs from all Sarcophagidae in having a very shallow bend in vein M, which ends in the wing tip.

In basic structure, the aedeagus of *Glutoxys* (Fig. 18) differs little from that of certain *Melanomya* (Figs. 38, 47 and others), and the genitalia apart from the aedeagus (Figs. 16, 17) are very much like the genitalia of *Melanomya nana* (Figs. 35-37). Also, the posterior thoracic spiracle is comparatively large; it intrudes forward into the meron so that the hind margin of the meron is concave (forward), as in *M. bicolor* (Fig. 5) or other Calliphoridae. Moreover, in general habitus *Glutoxys* bears a strong resemblance to *Melanomya* in many details, but it is not relatable to any of the Sarcophagidae on the basis of either habitus or significant characters.

For these reasons *Glutoxys* is best treated as a primitive calliphorid closely related to *Melanomya* and *Pseudopsodexia*.

Glutoxys elegans Aldrich
(Figs. 16-18, 25)

Glutoxys elegans Aldrich, 1929: 2-3 (holotype: male, Cat. No. 41813, U. S. National Museum, from "Santo Domingo," West Indies – presumably either Santo Domingo, = Ciudad Trujillo, Dominican Republic, or Santo Domingo, Cuba!); Townsend, 1935b: 260; 1938: 222; Lopes, 1973: 277-278.

A small fly, about 5 mm. long.

Male: Hinge plate absent; anteclypeus strongly convex; palpus yellow-brown.

Thorax and legs to about midlength of femora essentially yellow-orange in ground color, only the anterodorsal region of the mesoanepisternum (Fig. 25) somewhat infuscated; head cuticle, abdomen, legs beyond middle of femora and wing in the vicinity of the "knot" at the fork of vein Rs darker infuscated; postalar wall, metasternum, and mesokatepimeron asetulate; three evenly spaced marginal scutellars; subscutellum not developed; posterior thoracic spiracle about three times as high as broad, strongly slanted anteriorly (base to top), only the anterior flap of fringe hairs developed; anterior spiracle much smaller than posterior; posterior margin of meron shallowly excised to accommodate the posterior thoracic spiracle; basicosta orange; costal spine differentiated; apical posterodorsal and apical posteroventral bristles of hind tibia undifferentiated; dorsal setulae of hind tibia irregularly placed on apical half of tibia, not arranged into the usual regular dorsal row or pair of rows.

Second abdominal tergum with a row of erect hairs along posterior margin; third and fourth terga with both median marginals and strong median discals; fifth tergum with median discals; sixth tergum distinctly separated from first genital "tergum" by a band of membrane, with a single pair of middorsal bristles at the posterior edge; sixth sternum highly asymmetrical, very broad on left side near junction with first genital "tergum," narrowed to a point and well-separated from (and not articulated with) first genital "tergum" on right side; first genital "tergum" exceptionally short from front to back, with a pronounced middorsal excision so that midlength is shorter than midlength of sixth tergum; dorsolateral process of aedeagus undeveloped (Fig. 18); gonopod and paramere short, paramere with a lateral bristle (Fig. 16); surstylus not fused with epandrium (Fig. 17).

Material examined: the original type series consisting of the holotype and 6 paratypes, all males. No other specimens are known.

This species is peculiarly yellow-orange in body color, quite unlike *Melanomya*.

Genus *MELANOMYA* Rondani

Melanomya Rondani, 1856: 88, 214 (type-species: *Dexia nana* Meigen, by orig. desig.); Downes, 1965: 932.

Melanomyia (incorrect subsequent spelling): Schiner, 1862: 550; Herting, 1961: 4, 8.

Eggisops Rondani, 1862: 152, 177, 178, 233 (type-species: *Eggisops pecchiolii* Rondani, by monotypy); Townsend, 1938: 208. NEW SYNONYMY.

Engyzops Scudder, 1882: Part I, 123, Part II, 108, 112 (unjustified emendation of *Eggisops).*

Engyops Brauer and Bergenstamm, 1889: 124, 173, Fig. 192 (unjustified emendation of *Eggisops).*

Angioneura Brauer and Bergenstamm, 1893: 161, 187 (type-species: *Calobataemyia vetusta* Brauer and Bergenstamm, as *Myobia vetusta* Stein = *Medoria acerba* (Meigen), by monotypy).

Opsodexia Townsend, 1915: 20 (type-species: *Chaetona bicolor* Coquillett, by orig. desig.).

Phalacrodexia Townsend, 1915: 21 (type-species: *Chaetona flavipennis* Coquillett, by orig. desig.).

Opelodexia Reinhard, 1945: 74-75 (type-species: *Opelodexia artata* Reinhard = *Melanomya (Opsodexia) grisea* (Coquillett), by orig. desig. & monotypy).

Opelousia Townsend, 1919: 547 (type-species: *Opelousia obscura* Townsend, by orig. desig.).

Angioneurilla Villeneuve, 1924: 31 (type-species: *Tachina cyrtoneurina* Zetterstedt, by orig. desig.).

Opsodexiopsis Townsend, 1935a: 69 (type-species: *Opsodexia abdominalis* Reinhard, by orig. desig.).

Melanomya is characterized by the group description and the following: posterior surface of head with black hairs only; mesoanepisterum with setulae on anterodorsal region of a nearly uniform size, no setae strongly differentiated or standing out conspicuously from adjacent setae (Fig. 6); R_{4+5} with from one to six setae, these entirely restricted to knot at juncture with R_{2+3}.

European authors (*e.g.*, Emden, 1954; Séguy, 1941) have usually assigned *Dexia nana* (the type of *Melanomya*) to *Morinia* Robineau-Desvoidy, 1830, a genus name which antedates *Melanomya*. In this interpretation *Melanomya* is a junior subjective synonym of *Morinia*, and the Nearctic species would be correctly assigned to *Morinia*.

However, the type-species of *Morinia* is *M. velox* Robineau-Desvoidy, which Bezzi and Stein (1907) and Townsend (1938) synonymize with *Musca melanoptera* Fallén. If this synonymy is correct, then *Melanomya nana* and its relatives are clearly not assignable to *Morinia* in either a practical or theoretical sense. *Morinia melanoptera* does not have the subapical anterodorsal bristle on the midfemur, it lacks setae on R_{4+5}, it has a coxopleural streak, and the dorsolateral processes of the aedeagus (Figs. 32 and 33) are conspicuously elongate as in more typical Calliphoridae. There are also usually a few hairs on the mesokatepimeron in *Musca melanoptera*. These characters not only distinguish *Morinia* from *Melanomya*, but they remove it entirely from the *Melanomya* group as defined above.

Townsend (1938) recognized *Calobataemyia* and *Anthracomyia* as valid genera, although the type-species of both genera have usually been regarded as synonyms of *Musca melanoptera*. The nomenclature was further complicated by Séguy's (1941) use of *Morinia* for *Dexia nana* and *Dexia fimbriata* Meigen. He did not synonymize *Morinia velox* with either of these species, nor did he indicate an identity for it. He assigned *Musca melanoptera* to *Calobataemyia* Macquart, with *C. nigra* Macquart, the type-species of *Calobataemyia*, treated as a synonym. Further, I have found two species present in European material previously identified as *Morinia melanoptera* by various specialists. One of these species is figured here (Figs. 32 & 33). The second species appears to be the same as the species figured by Séguy (1941, Fig. 445) as *Calobataemyia melanoptera*. The discussion of the characters of *Morinia melanoptera* given above applies to either species.

Herting (1961) regarded the identities of both *Morinia velox* and *Calobataemyia nigra* as uncertain. This seems to be the most accurate assessment of the situation, and leads to the fewest problems of nomenclature. However, the identification of *Morinia velox* with *Musca melanoptera* also does not seem to lead to any problems with using *Melanomya* for the species treated here.

The sole species of subgenus *Eggisops* has been reared from snails (Audcent, 1942; Emden, 1954), as have *Melanomya cyrtoneurina, M. obscura* and *M. ordinaria* of subgenus *Angioneura*. On the basis of circumstantial evidence, *M. (Opsodexia) nox*, n. sp., is also a snail parasite, so this habit may be common to all members of the genus.

The uteri of subgenera *Angioneura* and *Opsodexia* seem to be of the oviparous type – at least dissections of dried females reveal a uterine membrane that suggests that the uterus in life could not retain very many eggs at one time for incubation. According to Thompson (1921), M. *(Eggisops) pecchiolii* (Rondani) is viviparous.

Key to the Subgenera and Species of *Melanomya*

1. Knob of halter dark infuscated, nearly black; vein A_1+CuA_2 short, extending only about half way along longitudinal axis to wing edge (subg. *MELANOMYA*, Palearctic, 1 species). . . . . *M. (M.) nana*

   Knob of halter pale, usually straw-colored; vein A_1+CuA_2 extending at least as a faint trace two-thirds or more distance along longitudinal axis to wing edge (Fig. 7). 2

2. Lunule setulate; 2 postsutural intra-alars, anteriormost bristle closer to transverse suture than to posterior bristle (subg. *EGGISOPS*, Palearctic, 1 species). . . . . *M. (E.) pecchiolii*

   Lunule not setulate; 1 postsutural intra-alar or, if 2, anterior bristle closer to posterior bristle than to transverse suture 3

3. Largest lateral scutellar bristle nearer to apex than to anterolateral corner of scutellum, rarely almost at midpoint; apical scutellars distinctly and often considerably smaller than lateral scutellars (Fig. 23); presutural acrostichals not differentiated; metasternum rarely setulate (subg. *ANGIONEURA*, Holarctic) 4

   Largest lateral scutellar bristle nearer anterolateral corner than to apex of scutellum, apical scutellars subequal to lateral scutellars (Fig. 24); presutural acrostichals almost invariably differentiated; metasternum setulate (subg. *OPSODEXIA*, Nearctic) . .9

4. Arista pubescent to short plumose, at least some hairs as long as twice diameter of thickened part of arista 5
   Arista virtually bare, longest hairs scarcely as long as diameter of thickened portion of arista (Palearctic) . . . . *M. (A.) cyrtoneurina*
5. Parafacials below lowermost frontal bristle with fine black setulae 6
   Parafacials without setae .7
6. Third antennal segment about twice length of second; prosternum setulate; metasternum usually setulate . . . . *M. (A.) ordinaria*
   Third antennal segment only about one and a half times length of second; prosternum usually without setae; metasternum without setae . . . . . *M. (A.) mitis*
7. Second antennal segment usually dark brown, rarely infuscated orange; femora and tibiae brownish to brownish-black in ground color, about the same color as the mesonotum . . . . *M. (A.) acerba* (Palearctic) and *M. (A.) obscura*
   Second antennal segment, femora, and tibiae yellowish to orangish, contrasting with the general ground color of the mesonotum 8
8. Palpus and abdomen brownish to brownish-black, concolorous with general ground color of thorax . . . . *M. (A.) abdominalis*
   Palpus yellowish; abdomen yellowish, at least on intermediate terga . . . . *M. (A.) flavescens*
9. Abdomen largely yellowish in ground color . . . . *M. (O.) bicolor*
   Abdomen blackish in ground color 10
10. Apical posterodorsal bristle of hind tibia larger than apical dorsal bristle; third abdominal tergum with median marginals . . . . *M. (O.) grisea*
    Apical posterodorsal bristle of hind tibia not or scarcely differentiated from setulae; third tergum without median marginals 11
11. Third antennal segment orangish; dorsal area of proepisternum setulate . . . . *M.(O.) flavipennis*
    Third antennal segment blackish; dorsal area of proepisternum without setae . . . . *M. (O.) nox*, n. sp.

Subgenus *MELANOMYA* Rondani

Melanomya Rondani, 1856: 88, 214 (type-species: *Dexia nana* Meigen, by orig. desig.); Townsend, 1938: 222, 227.

Melanomyia (incorrect subsequent spelling): Schiner, 1862: 550; Herting, 1961: 4, 8.

Lunule without setae; parafacialium setulate dorsally; arista plumose; presutural acrostichals differentiated, but not large; one large postsutural intra-alar near transverse suture, this bristle closer to suture than to the much smaller posterior bristle, latter located far posteriorly near supra-alar callus and often absent; one large lateral scutellar located about halfway from apex to anterolateral corner of scutellum; apical scutellar much smaller than lateral; vein A_1+CuA_2 short, extending half or less of distance along longitudinal axis from juncture with CuA_2 to wing edge; sixth tergum of female with very little pollen; epiphallus extending posteriorly at nearly a right angle to shaft of aedeagus (Fig. 38); acrophallus short and in line with longitudinal axis of aedeagus (Fig. 38); paramere with a lateral bristle (Fig. 36).

Townsend (1938) asserted that Rondani (1856) included two species when he originally described *Melanomya*, the type species being designated later by Brauer and Bergenstamm (1893). This is an error. Rondani included only one nominal species, *Dexia nana*, and this was expressly designated as type.

The Palearctic *Melanomya nana* is presently the only known species in this subgenus.

Melanomya (Melanomya) nana (Meigen)
(Figs. 34-40)

Dexia nana Meigen, 1826: 37 (holotype: Paris, Museum National d'Histoire Naturelle, from Germany).

Melanomya Nana: Rondani, 1856: 88.

Melanomya nana: Townsend, 1938: 227.

Melanomyia nana: Herting, 1961: 8.

Morinia nana: Séguy, 1941: 347-348, Figs. 451-452; Emden, 1954: 98.

Length, 3.0-5.0 mm.

Parafacialium setulate dorsally; second and third antennal segments blackish in ground color; arista plumose; palpus blackish.

Prosternum and dorsal area of proepisternum without setae; one presutural acrostichal differentiated, but not large; metasternum setulate or without setae; postalar wall asetulate.

Femora and tibiae blackish; apical posterodorsal and apical posteroventral bristles of hind tibia not or but weakly differentiated.

Third abdominal tergum without, and fourth tergum with or without, median marginals; third and fourth terga without discals; fifth tergum with erect discal hairs or large setulae; preabdomen blackish in ground color.

Basiphallus straight; acrophallus not elongate, less than twice as long as wide in lateral view, in line with general longitudinal axis of aedeagus; clear area at base of dorsolateral processes greatly shortened, almost slitlike; gonopod short, broad, and comparatively straight (Fig. 37); paramere only about twice as long as greatest width (Fig. 36); cercus extending a little farther ventrally than surstylus, with apical, free portion relatively stout in posterior view (Fig. 34); surstylus about three times as long as midwidth in lateral view (Fig. 35).

Subgenus *EGGISOPS* Rondani

Eggisops Rondani, 1862: 152, 177, 178, 233 (type-species: *Eggisops pecchiolii* Rondani, by monotypy); Townsend, 1938: 208. NEW STATUS, NEW SYNONYMY with genus *Melanomya*.

Engyzops Scudder, 1882: Part I, 123, Part II, 108, 112 (unjustified emendation).

Engyops Brauer and Bergenstamm, 1889: 124, 173, Fig. 192 (unjustified emendation).

Lunule and parafacialium setulate; arista plumose; presutural acrostichal differentiated; two postsutural intra-alars, anterior bristle closer to transverse suture than to posterior bristle; vein A_1+CuA_2 extending along longitudinal axis about four-fifths distance from junction with CuA_2 to wing edge; epiphallus extending posteriorly at nearly a right angle to shaft of aedeagus; acrophallus moderately elongate and extending posteroventrally at an angle to the shaft of the aedeagus (Fig. 44); postgonite with a lateral setula, without a differentiated bristle (Fig. 43).

The European *M. pecchiolii* is the only species currently included in this subgenus.

Melanomya (Eggisops) pecchiolii (Rondani)
(Figs. 41-44)

Eggisops pecchiolii Rondani, 1862: 178, 233 (holotype: in Florence, from Italy, *teste* Townsend, 1938).

Length, 5.0-9.0 mm.

Parafacialium setulate; second and third antennal segments blackish; arista plumose; palpus usually a dark infuscated orange.

Prosternum without setae; dorsal area of proepisternum setulate; presutural acrostichals differentiated; metasternum setulate or without setae; postalar wall with a few setulae.

Femora and tibiae blackish; apical posterodorsal bristle of hind tibia differentiated, larger than apical dorsal bristle; apical posteroventral bristle of hind tibia differentiated, not quite as large as apical anteroventral bristle.

Third and fourth abdominal terga with a marginal row of bristles; irregular discals present on fourth, fifth, and sometimes on third terga; abdomen blackish in ground color.

Basiphallus straight; acrophallus moderately elongate, broad at base, considerably narrower at tip, about one-third total length of aedeagus; clear area near middle of aedeagal shaft longer than width of aedeagus at that point (Fig. 44); gonopod moderately elongate and broad, with a rounded tip (Fig. 43); paramere about six times as long as midwidth, with a rounded tip and a lateral setula (Fig. 43); cercus not extending quite as far ventrally as surstylus, apical free (unfused with other cercus) portion moderately slender (Fig. 41); surstylus about twice as long as midwidth in lateral view (Fig. 42).

Subgenus *ANGIONEURA* Brauer and Bergenstamm

Angioneura Brauer and Bergenstamm, 1893: 161, 187 (type-species: *Calobataemyia vetusta* Brauer and Bergenstamm, as *Myobia vetusta* Stein = *acerba* (Meigen), by monotypy); Séguy, 1941: 335, 348-349; Herting, 1961: 4, 6; Crosskey, 1977: 14.

Opelousia Townsend, 1919: 547 (type-species: *Opelousia obscura* Townsend, by orig. desig.); Reinhard, 1929: 1, 5; Curran, 1934: 405, 408; Townsend, 1935b: 258, 260; 1938: 232; Hallock, 1940: 135, 137; Downes, 1955: 527, 529, 533, 535; Neck & Lopes, 1973: 188-189.

Angioneurilla Villeneuve, 1924: 31 (type-species: *Tachina cyrtoneurina* Zetterstedt, by orig. desig.). NEW SYNONYMY with genus *Melanomya*.

Melanomya (Angioneura): Downes, 1965: 932.

Opsodexia Reinhard: 1929: 5, 6 (in part).

Opsodexiopsis Townsend: 1935a: 69 (type-species: *Opsodexia abdominalis* Reinhard, by orig. desig.); Townsend, 1938: 210-211.

Lunule without setae; parafacialium commonly without setae; arista variable, from bare to short plumose; presutural acrostichals not differentiated; one postsutural intra-alar near posterior end of row; if two intra-alars, anterior bristle closer to posterior bristle than to transverse suture; one very large lateral scutellar located closer to apex than to anterolateral corner of scutellum, occasionally located almost at midpoint; vein A_1+CuA_2 extending along its longitudinal axis at least two-thirds the distance from its junction with vein CuA_2 to the edge of the wing; female sixth tergum mostly without pollen, retracted into hollow of fifth segment; basiphallus strongly curved posteriorly so that epiphallus roughly parallels axis of aedeagus beyond curved basiphallus; epiphallus curved, like an open "C"; acrophallus short, in line with longitudinal axis of distal part of aedeagus; paramere without setulae or bristles.

There are at least three European members of this subgenus, *M. acerba*, *M. cyrtoneurina* and *M. fimbriata* (Meigen) (Herting, 1961). I have not seen either *M. acerba* or *M. fimbriata*, but, judging from figures of the male genitalia (Séguy, 1941, Fig. 453), *M. acerba* is very close to the Nearctic *M. ordinaria* (Figs. 54-57). They may be the same. See Herting (1961) for a synopsis of these European species. The four known Nearctic species are very closely related members of a complex that is not yet well-understood. The differences among the male genitalia and external features are slight, and *M. obscura* itself may be a complex of cryptic species. Field and rearing studies appear to be essential now for significant progress in understanding the species of this group.

Melanomya (Angioneura) cyrtoneurina (Zetterstedt)
(Figs. 13-15)

Tachina cyrtoneurina Zetterstedt, 1859: 6135 (holotype: in Lund, from Sweden, *teste* Townsend, 1938).

Angioneura cyrtoneurina: Séguy, 1941: 349, 350-351; Herting, 1961: 6, 7.

Length, 4.0-5.0 mm.

Parafacialiam without setae; second and third antennal segments blackish; arista bare; palpus dark brown.

Prosternum and dorsal proepisternum without setae; presutural acrostichals not differentiated; metasternum and postalar wall without setae.

Legs entirely dark brown in ground color; apical posterodorsal bristle of hind tibia strongly differentiated. Abdominal terga 2-5 with a marginal row of bristles; males with rather irregular, erect setulae tending to a discal row on terga 4 and 5.

Basiphallus characteristically but less extremely curved than in other members of this subgenus, acrophallus short, slightly narrower than basiphallus (in lateral view), in line with longitudinal axis of aedeagus (Fig. 13); gonopod long and slender, curved at base; paramere several times longer than midwidth (lateral view), curved forward at extreme tip, without a differentiated lateral bristle (Fig. 14); cercus extending almost as far ventrally as surstylus; surstylus broader in lateral view than in any other member of the subgenus, less than twice as long as wide, with a marked constriction at upper fourth (Fig. 15); tenth sternum H-shaped, cross bar broad and weakly pigmented; lateral arms joined posteriorly to posterior arms of hypandrium; posterior arms of hypandrium curved medially so as to almost meet behind aedeagus.

Material examined: 4 males and 1 female as follows:

BELGIUM, East Flanders, Overmere, 4-vii-1959 (C. O. Berg).

These specimens were reared from a small, unidentified snail, which closely resembles in size and appearance the American snail from which *M. obscura* was reared by C. O. Berg and B. A. Foot at Ithaca, New York. As in *M. obscura,* the larvae pupated inside the snail shell with the front end of the puparium near the shell mouth. The puparia of these two species are very similar. Neither species has a prothoracic pupal horn protruded through the fourth segment of the puparium.

Melanomya (Angioneura) obscura (Townsend)
(Figs. 1, 3, 6-7, 19-20, 67-71)

Opelousia obscura Townsend, 1919: 547 (holotype: male, Cat. No. 22249, U. S. National Museum, from Opelousas, La., May, 1897); Reinhard, 1929: 1-3, 4; 1945: 76; Townsend, 1935b: 260; 1938: 232; Hallock, 1940: 137; Adams, 1941: 73-74; Downes, 1955: 522, 523, 529, Figs. 24-26; Neck & Lopes, 1973: 189-190; ?Ouellet, 1941: 138; ?Wray, 1950: 30.

Chaetona addenda West, 1925: 129 (holotype: female, Cornell University Collection, from Renwick (Stewart) Park, Ithaca, New York, Aug. 23, 1921 (L. S. West)).

Melanomya (Angioneura) obscura: Downes, 1965: 932.

Length, 3.5-7.0 mm.

Parafacialium without setae; second antennal segment blackish, occasionally infuscated yellow; third antennal segment blackish; arista long-pubescent, longest dorsal rays about twice the diameter of the thickened portion of the arista or a little longer (Fig. 1); palpus blackish to yellow.

Prosternum and dorsal area of proepisternum without setae; presutural acrostichals not differentiated; metasternum and postalar wall without setae.

Femora blackish to brown, occasionally yellowish at ends; tibiae blackish, sometimes infuscated yellow; apical posterodorsal and apical posteroventral bristles of hind tibia strongly differentiated.

Third and fourth abdominal terga with a marginal row of bristles; dorsal surface of third and fourth terga with only appressed setulae in female, but with erect setulae in male which often approach bristles in size on fourth tergum; fifth tergum with irregularly placed erect bristle-like setulae on dorsum in male.

Basiphallus strongly curved; acrophallus short and broad, in line with main axis of aedeagus (Fig. 69); gonopod elongate, curved at base; paramere several times as long as midwidth, without lateral bristle, tip curved, rounded, and membranous (Fig. 70); cercus not extending quite as far ventrally as surstylus, apical free portion slender, paralleling and close to other cercus, base broadly expanded; surstylus a little over twice as long as midwidth in lateral view (Fig. 68); pump sclerite as in Fig. 71.

Material examined: 128 males and 48 females from the following localities:

ONTARIO: Midland: 20-viii-1955 (J. G. Chillcott). QUEBEC: "Little Mt'l R.," St. Johns.: 9-vii-1936 (Shewell). SASKATCHEWAN: Attons Lake, Cut Knife: 3-vi-1940 (A. R. Brooks). YUKON: Marsh Lake: 10-vii-1948 (Mason & Hughes).

IA: Ames: 22-v-1949 (E. Manny); 16-viii-1952, 24-viii-1952, 6-ix-1954 (W. L. Downes); Clay Co.: 23-vi-1932 (Russell); Dickinson Co.: 12-vii-1935 (L. K. Cutkomp); Ft.

Dodge: 9-vii-1946, 10-ix-1946 (J. U. McGuire); 4 mi. E. Gilbert: 26-vii-1956 (Jean Laffoon); Jasper Co.: 6-vi-1951 (Keith Rhodebeck): Ledges State Park (Boone Co.): v-1956, 9-vi-1956, 12-vi-1956, 13-vi-1957, 15-vi-1957, 24-vii-1957, 30-vii-1955, 3-viii-1955 (Wm. L. Downes); 4-vi-1953, 31-vii-1955 (J. L. Laffoon); Mt. Pleasant: 7-viii-1949 (J. L. Laffoon); Oak Grove State Park (Sioux Co.): 18-viii-1953 (J. L. Laffoon); Sioux City: 1-vi-1927, 17-viii-1927 (C. N. Ainslie); 17-vi-1957, 24-vii-1953 (J. L. Laffoon); 18-ix-1951 (Wm. L. Downes). IL: 5 mi. N. E. Havana, 14-viii-1963 (Wm. L. Downes). IN: Lafayette: 11-v-1916, 12-v-1915, 13-v-1916, 21-v-1917, 11-vi-1915, 1-vii, 8-xi-1917 (J. M. Aldrich); 19-vi-1922 (E. W. Stafford). KS: Douglas Co.: "900 ft" (F. H. Snow). LA: Opelousas, v-1897. MI: Mecosta Co.: 5-vi-1946 (R. R. Dreisbach); Midland Co.: 9-vi-1940, 3-viii-1951 (R. R. Dreisbach); Schoolcraft Co. : 4-vii-1947 (R. R. Dreisbach). MN: Huston Co.: 2-vi-1951 (B. Ebel); Norman Co.: 4-vi-1923 (A. A. Nichol); Olmsted Co.: 13-vi-1906 (C. N. Ainslie). MO: Castlewood: 7-viii-1949 (W. L. Downes). NE: Fullerton: 19-viii-1949 (R. R. Dreisbach & R. K. Schwab). NJ: Atlantic City: 2-ix-1935 (Blanton & Borders); Trenton: 21-v-1905. NM: Socorro: (S. W. Williston). NY: Farmingdale, L. I.: 2-vi-1935 (Blanton & Borders); Ithaca: "Inlet Valley, LR-39A," 17-viii-1954 (C. O. Berg); "Inlet Valley, P. 5-viii-56, E. 11-viii-56, F-5666c" (B. A. Foote); "Booles Backw., Fall Creek, F-5675A, 20-viii-56," ex *Oxyloma ?retusa;* "Booles Backw., Fall Creek, F-5675, 20-viii-56," ex *Oxyloma ?retusa;* Ellis: "Tompkins, C_{II}, 30.VII.56, P. L. ?, E. 23VIII56, F. 5668F"; Old Forge, Long Lake: 23-viii-1922 (Shannon & Sibley). NC: L. Junaluska: 23-v-1954 (H. V. Weems Jr.). ND: Hamar: 27-7-1937 (C. L. Johnston); Kathryn (Barnes Co.): 20-vii-1939 (D. G. Denning); Knox: 28-7-1937 (R. H. Beamer). OH: Sugar Grove: 8-vi-1926 (D. G. Hall). PA: "All'y.": 27-vi-1891. SD: Pine Ridge: 9-vii-1957 (C. O. Berg). TX: College Station: 3-iv-1921, 6-iv-1921, 14-iv-1929, 18-iv-1930, 19-iv-1939, 20-iv-1920, 24-iv-1937, 27-iv-1930, 28-iv-1929, 3-v-1928, 3-v-1930, 9-v-1947, 11-v-1930, 17-v-1928, 18-v-1928, 29-v-1924, 12-vi-1929, 21-vi-1946 (H. J. Reinhard); Bentson State Park (Hidalgo Co.), 10.i.1966 (Donald R. Riley). VA: Boykins: 10-vi-1895; Great Falls: 14-v-1916 (C. H. T. Townsend). WI: Polk Co.: vii (Baker).

Knowlton (1936) reported a specimen determined questionably as *M. obscura* from Collinston, Utah. This is rather far from the usual range of the species, and the record is perhaps best treated as uncertain until the identification can be checked. Wray (1950) has reported this species from North Carolina, and Curtis Sabrosky (pers. comm.) has identified the species from that state. *Opelousia obscura* of Hendrickson (1930) is a misidentification of a sarcophagid, *Blaesoxipha hunteri* (Hough).

Reinhard (1929) reported rearing *M. obscura* from puparia found in shells of the snail *Succinea luteola* Gould, and Neck & Lopes (1973) have reported it from the same host. C. O. Berg and B. Foote (pers. comm.) have reared the species from a snail that was tentatively identified as *Oxyloma retusa* (the Ithaca, NY, specimens and one from Ellis, NY, indicated above). The puparium is recessed somewhat into the shell, and is curved to fit the shell. The anterior end of the puparium faces the shell opening. No pupal anterior spiracular horns are evident, and the puparial wall evidently lacks the small windows through which such horns are normally protruded. In all these respects the puparium of *M. obscura* is like that of *M. cyrtoneurina. M. ordinaria* has small spiracular horns protruded through the puparial wall and its larva leaves the snail shell to pupate.

Melanomya (Angioneura) flavescens (Reinhard)
(Figs. 23, 26, 78-82)

Opelousia flavescens Reinhard, 1929: 3, 4, 5 (holotype: male, Cat. No. 41985, U. S. Natl. Mus., from College Station, Tex. (H. J. Reinhard)); ?Wray, 1950: 30.

Melanomya (Angioneura) flavescens: Downes, 1965: 932.

Length, 4.0-5.0 mm.

This species is like *M. obscura* in all characters mentioned under that species except the following: second antennal segment clear yellowish (not infuscated); palpus yellow; femora and tibiae yellowish.

The spermathecae, spermathecal ducts and accessory gland linings are as in Fig. 26. They are rather different from any I have examined among the Sarcophagidae. The significance of the differences for *Melanomya* is not yet clear, as there are no adequate comparative studies of these structures.

Material examined: the holotype, 4 males and 4 females as follows:

TX: College Station, Jun. 3-11, 1946 (H. J. Reinhard).

Wray (1950) reported this species from North Carolina.

Apart from the color differences mentioned in the key and descriptions, the surstylus of *M. flavescens* (Figs. 78-79) seems to be a little broader and the tips of the cerci somewhat narrower (Fig. 79) than in *obscura* (Figs. 67-68). The tips of the gonopod and paramere (Fig. 81) are also more distinctly recurved in the specimen of *M. flavescens* illustrated here than in other members of the subgenus.

In the plates that follow, *M. obscura* is figured to a smaller scale than *M. flavescens.* The apparent size difference in the genitalia is not significant, since the male genitalia of *M. obscura* and *M. flavescens* are essentially the same size. The figures of the aedeagus (Fig. 80) and pump sclerite (Fig. 82) of *M. flavescens* apparently differ in a few respects from those of *M. obscura* (Figs. 69, 71), but these differences do not seem to be consistent.

This species is so exceedingly close to *M. obscura* that the two could be appropriately regarded as one species. Some specimens of *M. obscura* have sufficient yellow color that they begin to approach *M. flavescens* as one end of a continuum. However, since *M. obscura* itself may be a complex, *M. flavescens* should probably be treated as distinct until more material is available for study.

Melanomya (Angioneura) abdominalis (Reinhard)
(Figs. 72-77)

Opsodexia abdominalis Reinhard, 1929: 6-7, 9 (holotype: male, Cat. No. 41986, U. S. Natl. Mus., from Fabyans, N. H., Aug. 19, 1914 (C. H. T. Townsend), on flowers of *Solidago*); Hallock, 1940: 138; ?Ouellet, 1941: 138.

Opsodexiopsis abdominalis: Townsend, 1935a: 69; 1935b: 255; 1938: 210.

Melanomya (Angioneura) abdominalis: Downes, 1965: 932.

Parafacialium usually without setae (one setula below the lowermost frontal bristle in one specimen); second antennal segment orangish; third segment blackish; longest dorsal rays of third aristal segment about three times as long as diameter of thickened portion of arista; palpus blackish.

Prosternum and dorsal area of proepisternum without setae; presutural acrostichals not differentiated; metasternum without setae; postalar wall with a few setulae (in the two specimens examined–this character will probably prove variable in this species).

Femora yellowish, forefemur somewhat infuscated; tibiae yellow; apical posterodorsal bristle of hind tibia differentiated but rather smaller than apical anteroventral bristle.

Third abdominal tergum with median marginals, fourth with a marginal row of bristles; erect setulae present on dorsal surface of fourth tergum of male.

Basiphallus more slender and elongate than in all other *Melanomya,* strongly curved; acrophallus short and broad, more or less in line with main longitudinal axis of aedeagus, at narrowest a little wider than narrowest part of the basiphallus (Fig. 77); gonopod greatly elongate and slender, very strongly curved over basal two-thirds; paramere several times longer than midwidth, without lateral bristle, tip abruptly curved, rounded and unpigmented (Fig. 73); cercus not extending quite as far ventrally as surstylus, apical free portion slender, paralleling and close to other cercus, base moderately expanded (Fig. 72); paralobe about three times as long as midwidth in lateral view (Fig. 74); pump sclerite as in Fig. 75.

Material examined: the holotype and one male as follows:

MI: Douglas Lake, 7-13-1928 (Charles Martin).

Melanomya (Angioneura) ordinaria (West)
(Figs. 54-57)

Chaetona ordinaria West, 1925: 129 (holotype: female, Cornell Univ. collection, from "Ausable River to Wood's Farm" near base of Mt. McIntyre, Adirondack Park, N. Y., 1-vii-1923 (L. S. West)).

Melanomya (Angioneura) ordinaria: Downes, 1965: 932.

Length, 4.0-6.0 mm.

Parafacialium with setulae on dorsal half or more in a continuous but irregular series with orbital setulae; second and third antennal segments blackish; arista long-pubescent to short-plumose, the longest dorsal rays from 1.5 to slightly more than 2 times as long as thickest portion of arista.

Prosternum setulate; dorsal area of proepisternum without setae; presutural acrostichals not differentiated; metasternum usually setulate; postalar wall usually with one to three setulae, seldom without.

Femora blackish; tibia blackish on basal third but usually yellowish distally; apical posterodorsal bristle of hind tibia absent or but slightly differentiated, apical posteroventral bristle absent or small, always much smaller than apical anteroventral bristle.

Third abdominal tergum without median marginals (but with a row of decumbent setulae somewhat larger than the discal setulae); fourth tergum with a marginal row of bristles; no median discals except for an irregular row on fifth tergum.

Basiphallus strongly curved; acrophallus short and broad, in line with main longitudinal axis of aedeagus, narrowest width not as great as narrowest width of basiphallus (Fig. 56); gonopod long and slender, curved at base; paramere several times longer than midwidth, without lateral bristle, tip curved, rounded, and membranous (Fig. 57); cercus extending about as far ventrally as paralobe, apical free portion diverging from other cercus, slender, base moderately broadened (Fig. 54); surstylus about three times as long as midwidth in lateral view (Fig. 55).

Material examined: the holotype, 5 males and 13 females, as follows:

ALBERTA: Banff, 29-v-1922 (C. D. B. Garrett). QUEBEC: Coaticook, 10-ix-1913 (J. I. Beaulne); Quarry Is., Mingan, 13-vi-1929 (W. J. Brown); Wakefield, 22-vi-1946 (G. S. Walley). SASKATCHEWAN: Great Deer, 25-iv-1949 (J. R. Vockeroth).

AK: Curry, 29-vi-1952 (W. R. Mason). MI: Ann Arbor, 20-vii-1927 (N. K. Bigelow); same data as prededing, but 18-iv-1927. NY: "Inlet Valley," Ithaca, 6 dates from 17-viii to 31-viii-1954 (C. O. Berg); same data as preceding except 13-viii-1956 (B. Foote), P. 20-viii-1956, E. 27-viii-1956, reared from snail *Oxyloma ?retusa;* as preceding except 6-vii-1956 (B. Foote), P. 12-vii-1956, E. 19-vii-1956, reared from snail *Oxyloma ?retusa;* Oneida L., lab. reared, 1-ix-1956, P. 2-ix-1956, E. 12-ix-1956, parasite on *Succinea ovalis.*

According to Dr. B. A. Foote's data the full grown larva of this species leaves the snail to pupate. The anterior spiracular horns of the pupa are protruded through the typical small windows in the fourth segment of the puparium. *Melanomya obscura* differs in both of these features. The "P." and "E." in the preceding list occur on the labels as such, and apparently stand for "pupated" and "emerged" respectively.

Melanomya (Angioneura) mitis (Reinhard)
(Figs. 8-12)

Opelousia mitis Reinhard, 1945: 76-77 (holotype: male, H. J. Reinhard collection, now in the Canadian National Collection, from Gillam, Manitoba, 10-viii-1937 (D. G. Denning)).

Melanomya (Angioneura) mitis: Downes, 1965: 932.

Length, about 4.0 mm.

Parafacialium setulate below lowermost frontal bristles; second and third antennal segments blackish; arista very short plumose on slightly less than basal half of arista.

Prosternum bare or setulate; dorsal proepisternum without setulae; presutural acrostichals not differentiated; metasternum without setae; postalar wall setulate or not.

Femora blackish; tibiae yellowish on distal half; apical posteroventral bristle of hind tibia not differentiated, apical posterodorsal bristle only weakly differentiated.

Fourth tergum with a marginal row of bristles; third, with a weakly developed row; premarginal setae of dorsal and ventral aspects of preabdominal terga erect, hair-like on terga 2 and 3, bristle-like on terga 4 and 5.

Basiphallus curved over its entire length, epiphallus not at a right angle to shaft at point of origin, almost in line with axis of extreme base of shaft; acrophallus short and narrowed to half width of aedeagus proper (Fig. 8); gonopod slender, but not strongly curved at base; paramere approximately six times as long as midwidth (lateral view), tip somewhat curved and unpigmented (Fig. 10); cercus extending a little further ventrally than surstylus, apical free portion slender and diverging gradually from other cercus, base moderately expanded (Fig. 12); surstylus about three times as long as midwidth in lateral view (Fig. 11).

Material examined: the holotype and one other male as follows:

MI: Ionia, 9-vi-1949 (Ryoji Namba).

Subgenus *OPSODEXIA* Townsend

Opsodexia Townsend, 1915: 20 (type-species: *Chaetona bicolor* Coquillett, by orig. desig.); West, 1928: 823; Reinhard, 1929: 5, 6; Curran, 1934: 404, 406, 408; Townsend, 1935a: 69; 1935b: 255, 256; 1938: 209-211, 212; Hallock, 1940: 135, 137; Reinhard, 1945: 74; Crosskey, 1977: 13.

Phalacrodexia Townsend, 1915: 21 (type-species: *Chaetona flavipennis* Coquillett, by orig. desig.); Townsend, 1935b: 256; 1938: 211-212.

Opelodexia Reinhard, 1945: 74-75 (type-species: *Opelodexia artata* Reinhard = *Melanomya (Opsodexia) grisea* (Coq.), by orig. desig. & monotypy).

Melanomya (Opsodexia): Downes, 1965: 932

Lunule asetulate; parafacialium setulate; arista plumose; one differentiated presutural acrostichal (or rarely in *M. bicolor,* none); one or two postsutural intra-alars, anterior bristle never closer to transverse suture than to posterior bristle; vein A_1+CuA_2 extending along its longitudinal axis at least two-thirds of distance from juncture with CuA_2 to wing edge; female sixth tergum pollinose; epiphallus extending posteriorly at nearly a right angle to longitudinal axis of middle third of aedeagus; acrophallus considerably elongate and extending more or less posteroventrally at an angle to longitudinal axis of aedeagal shaft (aedeagus considered as extruded with main axis directed ventrally); paramere with a lateral bristle.

Melanomya (Opsodexia) bicolor (Coquillett)
(Figs. 21, 24, 45-49)

Chaetona bicolor Coquillett, 1899: 221 (holotype: male, Cat. No. 4121, United States National Museum, from White Mts., NH. (H. K. Morrison)).

Opsodexia bicolor: Townsend, 1915: 20; 1935b: 256; 1938: 209; Johnson, 1925: 210; West, 1928: 823; Reinhard, 1929: 5, 6, 7, 9; Brown, 1934: 249; Hallock, 1937: 259; 1940: 137-138; ?Wray, 1950: 30; Neck & Lopes, 1973: 183, 190-192, Figs. 38-44.

Melanomya (Opsodexia) bicolor: Downes, 1965: 933.

Length, 6.0-7.5 mm.

Parafacialium setulate below level of frontal bristles; second antennal segment orange, infuscated with brown, third segment blackish except for orangish base; arista long-plumose; palpus orange, rarely brownish.

Prosternum and dorsal area of proepisternum setulate; one pair of differentiated acrostichals except occasionally none differentiated; metasternum setulate; postalar wall with one to a few setulae.

Femora entirely yellowish to brownish on basal half; tibiae yellowish; apical posterodorsal bristle of hind tibia differentiated but smaller than apical dorsal bristle, apical posteroventral bristle not differentiated.

Third abdominal tergum with median marginals or a marginal row; fourth tergum with a marginal row; setulae of dorsal aspect of third and fourth terga rather decumbent in female, erect in male.

Basiphallus not curved; acrophallus elongate, widened gradually to a broadly expanded tip, bent posteriorly at base from main longitudinal axis of aedeagus, about a third the length of aedeagus (Fig. 47); gonopod relatively straight and short, edges in lateral view converging to an acuminate tip; paramere about five times as long as midwidth, with a lateral bristle (Fig. 48); surstylus extending much farther ventrally than cercus; cercus with apical free (unfused) portion very abbreviated; surstylus about four times as long as midwidth, less in posterior view because the flared lateral margins widen the dorsal profile (Figs. 45-46); pump sclerite as in Fig. 49.

Material examined: the holotype, 73 males, and 14 females, as follows:

QUEBEC: Gaspe Bay: 18-vii-1931 (J. M. Aldrich); Laniel: 15-vi-1944 (A. R. Brooks).

GA: Blood Mt.: 12-vi-1941 (P. W. Fattig); Neel Gap: 3-vi-1946 (P. W. Fattig). IL: Bell Smith Springs: 12-iv-1961 (Wm. L. Downes). KY: Kentucky Ridge State Forest: 1200', 11-vi-1947; "Sta. Pineville N IV Ky. Ridge Forest, Beech, 20-ix-1947. MD: College Park: 9-vi-1935, 19-ix-1937, 27-ix-1936 (C. T. Greene); Plummer's Id.: 25-viii-1914 (R. C. Shannon), at light. ME: Bar Harbor [Mt. Desert Id.]: 11-ix-1912; Mt. Desert Id.: "11 Sept 0, 10572". MA: Auburndale: viii-1913, ix-1920 (C. W. Johnson); Chester: 24-vii-1912, 4-viii-1911, 5-viii, 11-viii-1911 (C. W. Johnson); Great Barrington: 15-vi-1915 (C. W. Johnson); Petersham: 26-viii-1920 (L. H. Taylor). MI: St. Joseph Co.: 5-ix-1954 (R. R. Dreisbach). NH: "Base Mt. W., Aug. 30, *Solidago*." NJ: Iona: 2-x-1910; Riverton: 20-vi-1909; Wenonah: 21-viii-1910, 2-x-1910. NY: Whiteface Mt., Adirondacks: 4-vii (J. M. Aldrich). OH: Sugar Grove: 8-vi-1926 (D. G. Hall); Summit Co. : 9-vi-1937 (Louis J. Lipovsky). PN: Germantown: 27-iii-1904 (Harbeck); 4-vi-1905 (W. R. Walton); 18-vi-1905 (C. W. Johnson); 26-vi; 17-vii-1909 (Harbeck); Hechton Mills: 15-vi-1909 (W. R. Walton); Roxborough: 7-vi-1908; 10-vi-1911 (Geo M. Greene); 27- vi-1908 (Harbeck); Upsal: 18-vi-1906. TN: Gatlinberg: "3J Pine Heath, GSMNP, 3500'," 19-vii-1947 (R. H. Whittaker). VA: Great Falls: 12-vi (N. Banks). VT: Bolton Mt.: 30-viii; Mt. Equinox: 5-vi-1910. WV: Cheat Mts.: vi (H. H. Smith); Cranberry Glades (Pocahontas Co.): 16-vii-1955 (C. W. Sabrosky).

Wray (1950) has reported this species from North Carolina; Neck & Lopes (1973) have reported it from New Jersey and New York; Hallock (1940) reported it from several localities in New York, and stated that it had been collected on flowers of *Solidago*, *Baccharis* and other Compositae. Brown (1934) reported the species from Ontario.

Melanomya bicolor is probably a complex of two or more species. The females of one form have a rather large curved ovipositor that resembles that of *Pseudopsodexia horebana* Dodge, but none of the specimens of the second form, which appears to have a smaller ovipositor, are in good condition. I have been unable to distinguish consistent forms in the male sex. The tip of the anterior face of the midfemur of *M. bicolor* also has a larger than usual ventral flange (Fig. 21), which is extraordinarily developed in *Pseudopsodexia horebana*. This seems to confirm the placement of *Pseudopsodexia* in the *Melanomya* group.

Melanomya (Opsodexia) flavipennis (Coquillett)
(Figs. 62-66)

Chaetona flavipennis Coquillett, 1902: 121-122 (holotype: male, Cat. No. 6237, United States National Museum, from Vinton, Ohio, 6-v-1900 (James S. Hine)).

Phalacrodexia flavipennis: Townsend, 1915: 21; 1935b: 256; 1938: 211.

Melanomya (Opsodexia) flavipennis: Downes, 1965: 933.

Length, about 8.0 mm.

Parafacialium setulate on dorsal half; second and third antennal segments orange, latter rather strikingly so; arista long-plumose.

Prosternum and dorsal area of proepisternum setulate; one strong presutural acrostichal; metasternum setulate; postalar wall without setae (this feature will probably not prove consistent within the species).

Femora and tibiae brownish; neither apical posterodorsal nor apical posteroventral bristles of hind tibia differentiated.

Third abdominal tergum without and fourth tergum with median marginals; median discals absent.

Basiphallus moderately curved; acrophallus elongate and bent posteroventrally from main longitudinal (vertical) axis of aedeagus, a little more than a fourth length of aedeagus (Fig. 62); gonopod slender, elongate, curved at base (Fig. 64); paramere about three times as long as midwidth, with an acute hooked tip and a lateral bristle (Fig. 63); cercus extending farther ventrally than surstylus, moderately wide in posterior view, base little broadened (Fig. 65); surstylus about three times as long as midwidth in lateral view (Fig. 66).

Material examined: the holotype male and allotype female, both with same collection data.

Melanomya (Opsodexia) grisea (Coquillett)
(Figs. 58-61)

Chaetona grisea Coquillett, 1899: 222 (holotype: male, Cat. No. 4124, United States National Museum, from Georgia).

Opelodexia artata Reinhard, 1945: 75-76 (holotype: male, H. J. Reinhard collection now at the Canadian National Collection in Ottawa, from Greenville, N. C., 10-vi-1921).

Melanomya (Opsodexia) grisea: Downes, 1965: 933.

Length, 5.5 mm.

Parafacialium setulate dorsally; second antennal segment dark infuscated orange, third segment orangish at base but blackish distally; arista plumose; palpus orange at tip, black at base.

Prosternum setulate or bare; dorsal area of proepisternum without setae; one presutural acrostichal differentiated; metasternum setulate; postalar wall with a few setulae.

Femora and tibiae blackish; apical posterodorsal bristle of hind tibia strongly differentiated, larger than apical dorsal bristle; apical posteroventral bristle of hind tibia differentiated, but smaller than apical anteroventral bristle.

Third abdominal tergum with median marginals, fourth tergum with a marginal row; no discals except for an irregular row on the fifth tergum; preabdomen blackish-brown in ground color.

Basiphallus strongly curved, but not quite to the extent found in subgenus *Angioneura;* acrophallus decidedly elongate, nearly parallel-sided, about a third length of aedeagus, bent posteroventrally from main longitudinal (vertical) axis of aedeagus (Fig. 60); gonopod elongate, curved, tip slightly broadened and rounded; paramere several times longer than midwidth in lateral view, with a lateral bristle and a curved, rounded tip (Fig. 61); cercus extending farther ventrally than surstylus, relatively broad and not greatly widened at base (Fig. 58); surstylus about four times as long as midwidth in lateral view (Fig. 59).

Material examined: the holotype of *M. grisea* and three other males as follows:

FL: Levy Co., 3-iv-54 (H. V. Weems, Jr.). IL: Urbana, 9-viii-1920 (J. R. Malloch). GA: Neel Gap, 15-v-49 (P. W. Fattig).

Reinhard (1945) also reported the species from Fairfax, South Carolina, 16-vi-1932.

I have not examined the holotype of *M. artata.*

Melanomya (Opsodexia) nox, Downes, n. sp.
(Figs. 50-53)

Length, 6.5 mm.

Parafacialium setulate; second and third antennal segments blackish; arista medium plumose for about two-thirds of its length; palpus infuscated orange to blackish.

Prosternum setulate; dorsal area of proepisternum without setae; one large presutural acrostichal differentiated; metasternum setulate; postalar wall without setae.

Femora and tibiae brownish-black; apical psterodorsal and apical posteroventral bristles of hind tibia not or but weakly differentiated.

Third and fourth abdominal terga without median marginal or median discals, fifth tergum without median discals; preabdomen brownish-black in ground color.

Basiphallus slightly curved; acrophallus greatly elongate, slender, nearly parallel-sided, bent posteroventrally from main longitudinal, vertical axis of aedeagus, comprising a little more than a third of the total length of the aedeagus (Fig. 52); gonopod elongate, straight, with a bluntly pointed tip; paramere about six times as long as midwidth (lateral view), with a curved blunt tip and a lateral bristle (Fig. 53); cercus extending distinctly farther ventrally than surstylus, apical unfused part paralleling and very close to adjacent cercus (Fig. 50), in lateral view, distinctly bent forward near tip (Fig. 51); surstylus almost four times as long as midwidth in lateral view (Fig. 51).

Holotype, male, University of Kansas collection, from Summit Co., Ohio, 6-9-1937 (Louis J. Lipovsky).

Paratypes, IA: 1 female, ?Ledges State Park, Boone Co., Schaffner & Widdows, in the New York State Museum at Albany, New York. TN: 1 male, "2E hemlock For., Gatlinburg, GSMNP 4000', NE, Sweeps," 29-vi-1947 (R. H. Whittaker), in the U. S. Natl. Museum.

The Iowa specimen emerged about 15-iv-1957 in a closed laboratory terrarium that had been stocked with snails from the Ledges State Park, but some moss and dirt from Ames, Iowa had been added to the terrarium. In view of the known biology of this genus, it seems most likely that the specimen developed on the unidentified snails, and would then be from the Ledges State Park in Boone Co., Iowa.

The holotype has cell r_{4+5} (cell r5, or apical cell) closed in the margin of the right wing tip. It is open in the left wing.

Genus *PSEUDOPSODEXIA* Townsend

Pseudopsodexia Townsend, 1935a: 69 (type-species: *Opsodexia cruciata* Reinhard, by orig. desig. and monotypy); Townsend, 1935b: 256; 1938: 212.

This genus is defined within the *Melanomya* group by the following characters: parafacialium with a few very fine setulae on dorsal half; arista plumose; third antennal segment with fine, white pile coat shorter than in *Melanomya,* the pile units not quite as long as thickened portion of arista; prosternum setulate or without setae; dorsal area of proepisternum setulate; one presutural acrostichal differentiated; a single well-differentiated bristle directed anterodorsally near anterodorsal corner of mesoanepisternum (as in Fig. 25, cf. Fig. 6); knob of halter blackish.

The two species of this genus have a single frontal bristle just above the base of the antennae very much larger than the other frontals.

Key to the Species of *Pseudopsodexia*

Second and third abdominal terga with median discals; prosternum setulate; third antennal segment about 2. 5 times as long as second. . . . . *P. cruciata*

Second and third abdominal terga without median discals; prosternum without setae; third antennal segment about 3. 5 times as long as second . . *P. horebana*

Pseudopsodexia cruciata (Reinhard)
(Figs. 27-31)

Opsodexia cruciata Reinhard, 1929: 7-9 (holotype: male, Cat. No. 41987, United States National Museum, from Havana, Cuba (Baker)).

Pseudopsodexia cruciata: Townsend, 1935a: 69; 1935b: 256; 1938: 212; Dodge, 1965: 500.

Length, 5.5 mm.

Second and third antennal segments blackish, third segment about 2.5 times as long as second; palpus black.

Prosternum setulate; three large, more or less evenly spaced marginal scutellars; basicosta blackish; costal spine vestigial.

Femora and tibiae blackish; apical posterodorsal and apical posteroventral bristles of hind tibia not differentiated.

Third abdominal tergum with both median marginals and median discals, fourth tergum with median discals and a marginal row.

Basiphallus very short, not curved, acrophallus slender, bent posteriorly at base from main longitudinal axis of aedegus (Fig. 29); gonopod short and broad in lateral view (Fig. 31); paramere about four times as long as wide in lateral view, nearly straight, with a small lateral seta (Fig. 27); cercus extending below tip of surstylus, base not noticeably expanded, inner margins of free, apical portion diverging from other cercus toward tip (Fig. 28); surstylus unusually broad in lateral view, slightly more than twice as long as greatest width (Fig. 30).

Material examined: The holotype male was examined, figured and described in 1956.

An earlier attempt to spread the male genitalia had damaged the holotype; the tip of the left cercus was missing and the aedeagus had been broken. The aedeagus is either short or has a middle portion missing as suggested by the dotted lines of Fig. 29. No other specimens are known.

Pseudopsodexia horebana Dodge

Pseudopsodexia horebana Dodge, 1965: 498, 500, Figs. 9, 9a (holotype: female, Washington State University collection at Pullman, from N. E. slope of Mt. Horeb, Portland, Jamaica, Nov. 21, 1954 (T. H. Farr)).

Length, 4.0 mm.

Second and third antennal segments blackish, third segment about 3.5 times as long as second; palpus blackish, clavate; prosternum without setae; scutellum with two large marginals; basicosta blackish; costal spine not differentiated; femora and tibiae blackish; apical posterodorsal and apical posteroventral bristles of hind tibia not differentiated; median marginals present, median discals absent on third and fourth abdominal terga.

Each femur of this species has an unusually well-developed flange projecting ventrally from the apical region of the anteroventral edge. If the tibia is folded flat against the femur, the base of the former is concealed in frontal view by the flange. *Glutoxys elegans* shows only a very slight comparable expansion of this flange.

The female of *P. horebana* possesses a sort of ovipositor, apparently consisting mainly of the sixth tergum. The latter resembles an inverted trough rather evenly curved over its whole length, with the tip directed ventrally. It is not very long, and it is virtually apollinose, appearing shining black.

Material examined: The preceding description was drawn from a single female that was in the United States National Museum in 1956. It had the same label data as the holotype, and may be the same specimen. If not, the holotype has not been examined.

SYSTEMATIC POSITION

As mentioned earlier, species of the *Melanomya* group have been assigned at various times to each of the four tachinoid families (Calliphoridae, Rhinophoridae, Sarcophagidae, Tachinidae). Such scattering results in part from inadequate information; it also results from differing interpretations of the significance of certain characters.

The Nearctic species were collected into a single calliphorid genus in the *Catalog of the Diptera of America North of Mexico* (Downes, 1965). Since then, Neck & Lopes (1973) and Crosskey (1977) have questioned the inclusion of the species in a single genus. Crosskey removed subgenera *Angioneura* and *Melanomya* to the Rhinophoridae (as genera), but retained subgenus *Opsodexia* and presumably *Eggisops,* which was not mentioned in the *Catalog,* as calliphorid genera. As Crosskey noted, space limitations precluded explaining the classification in the *Catalog* itself. I had hoped to present the underlying rationale soon afterwards, but the matter proved much more difficult than expected, and several issues have remained unsolved. The following material summarizes progress to date.

The Primitive Tachinoid, Unexpected Parallelisms

Hennig (1966) and a number of his followers have been most vocal in advocating phylogenetic methods as a means for developing a more rigorous approach to taxonomic work. From their perspective, such methods should be especially useful for establishing a sound classification of the major calyptrate groups, and they should help place *Melanomya* and other problem groups more accurately among their relatives. Nevertheless, the major problems of calyptrate classification have not yielded to phylogenetic methods. Apparently, a fundamental assumption of Hennigian phylogenetics is vitiated by the numerous parallelisms and convergences within the Calyptratae. To give two brief examples of parallelisms:

1) The convexly developed subscutellum ("postscutellum") of the Tachinidae has usually been regarded as a defining feature of the Tachinidae, and in the overwhelming majority of the species it is very well-developed, as in Fig. 2. Apart from Crosskey's paper (1977) there are few clues in the literature that the usual tachinid subscutellum should not be interpreted as a derived (apomorphic) character-state of that family. It is certainly one of the most useful taxonomic characters among the Calyptratae. But there are some disconcerting deviations in its development and distribution.

Besseria brevipennis (Loew), *Eutrixa exilis* (Coquillett), *Eugymnogaster montana* (Coquillett), and *Bezzimyia* sp. are four Nearctic tachinids that have only small subscutella. Herting (1961) mentions that the European *Litophasia hyalipennis* (Fallén) (as *Lithophasia*) has a reduced subscutellum, and Crosskey (1977) indicates that several Australian species, which are evidently correctly placed in the Tachinidae, have only feebly developed subscutella. The genera with small subscutella do not constitute a distinct monophyletic assemblage among the Tachinidae, and so we have a problem: Have all these small subscutella arisen by parallel reduction within the Tachinidae?

This can hardly be the case, because the species with the small subscutella also exhibit many other primitive characters. Apparently we have misinterpreted the character-states of the subscutellum: the primitive state is not the absence of a convex subscutellum, but the presence of a small one, such as in Fig. 3.

This interpretation is in accord with a wide body of data. Small convexities occur in some Calliphoridae (*Eggisops,* treated here as a subgenus of *Melanomya,* is one whose placement in the Calliphoridae has not been so controversial) and in the Rhinophoridae. An undescribed South American sarcophagid near *Neophyto* (Sarcophagidae, Sarcophaginae) has a small subscutellum. Convex subscutella, in fact, occur rather widely both inside and outside the Calyptratae; they occur in certain muscoids, oestroids, conopids, syrphids, and others. The most plausible interpretation is that a convex subscutellum, probably small in size, represents the primitive state for calyptrates. This subscutellum has been lost independently on more than one occasion within the Calliphoridae, on more than one occasion within the Sarcophagidae and several times within the Muscoidea. But within the Tachinidae the subscutellum has become enlarged independently in more than one lineage. It has also become independently enlarged in the Ameniinae (Calliphoridae), which were at one time thought to be Tachinidae because of the large subscutellum. The South American Mesembrinellinae (Calliphoridae) also have a well-developed subscutellum.

2)It has been assumed that the angularly bent vein M (M_{1+2}) is an apomorphic feature of the Tachinoidea (Griffiths, 1972). However, the European *Cinochira atra* Zetterstedt does not have an angular bend in vein M (Séguy, 1941, Fig. 455; Emden, 1954, Fig. 1-I), nor does the Nearctic *Eugymnogaster montana. Freraea albipennis* Zetterstedt, a European tachinid, is clearly unrelated to *Cinochira,* but it similarly has an unbent vein M (Emden, 1954, Fig. 4-M). Again, we either propose a series of *ad hoc* hypotheses to explain away these unbent veins as secondary developments (or possibly atavisms) within the Tachinidae, or we more plausibly interpret them as persistences of the primitive character-state. But, if the latter, then the angularly bent vein M has arisen independently on more than one occasion within the Tachinidae alone.

It also follows that, contrary to the conventional assumption, the common ancestor of the Tachinoidea lacked an angularly bent vein M—which then must have arisen independently within the sarcophagid-calliphorid lineage. This hypothesis is supported by the observation that most species of *Melanomya,* as *M. obscura* (Fig. 7), have only a shallow bend in vein M. The bend is particularly shallow in *M. cytoneurina.* As is obvious and well known, an angularly bent M has arisen independently in *Musca* and other Muscoidea.

Vein A_1+CuA_2 ("first Anal") extends to the wing margin as a faint trace in *Siphona* and certain unidentified Dexiinae (Tachinidae). This feature is characteristic of the Anthomyiidae, and is clearly primitive in relation to the shortened state. It is an unexpectedly primitive character for the Tachinidae, and discordant with the idea that the angularly bent vein M and shortened vein A_1+CuA_2 are apomorphic features of the Tachinoidea. Hennig and Griffiths (Griffiths, 1972) explain the long vein A_1+CuA_2 of *Siphona* as a secondary development within the Tachinidae. However, the unbent vein M and unshortened vein A_1+CuA_2 occur in species with more than the usual number of primitive wing characters. It is more consonant with available data to interpret the long vein A_1+CuA_2 as primitive in the Tachinidae in which it occurs. Moreover, some specimens of *Melanomya cyrtoneurina* have vein A_1+CuA_2 extending fully to the wing margin (in other specimens it ends just short of the wing margin), which provides additional support for the idea that this is the primitive character-state for the tachinoid calyptrates.

The preceding examples emphasize the point that the common ancestor of the Tachinoidea differed materially and conspicuously from its modern descendents; it exhibited characters much more primitive than would ordinarily be expected.

This point is supported by information from the Sarcophagidae. A list of nearly 60 primitive character-states, derived from a study of a great many sarcophagids, describes *Neophyto hirculus* (Coquillett) with remarkable accuracy. The list also fits another sarcophagid, *Macronychia confundens* (Townsend), almost as well. Both species are atypical sarcophagids, especially in head conformation. At one time they were isolated with certain relatives in their own subfamily, the "Amobiinae," because of their numerous resemblances and their deviations from the usual sarcophagid habitus. But *Neophyto* and *Macronychia* are not related genera; they belong to different subfamilies (Sarcophaginae and Miltogramminae, respectively).

A list of primitive character-states derived from a study of the Tachinidae is essentially identical to the sarcophagid list, and certain species, as *Eutrixa exilis* or *Microphthalma* sp. approximate this pattern in most details. These Sarcophagidae and Tachinidae resemble each other to a surprising degree, especially in head features, not because they are related, but because they possess so many primitive characters in common.

Limiting the discussion to just the head, the hypothetical common ancestor of the tachinoids exhibited several salient features: eye exceptionally small for tachinoids, proclinate orbitals present in both sexes; antennae short, third segment almost globular; arista bare and short; frontogenal sutures bending medially and closely approximated at vibrissal level, vibrissae not distinctly differentiated and vibrissal angle (in lateral profile) not distinctly developed; proboscis short and stout; genal groove (transverse impression) broad and conspicuous. None of these are features of the "typical" modern calyptrate.

The reasoning entailed in identifying the primitive head features of the tachinoid progenitor is simple and straightforward; they would be identified as such by almost any competent systematist who had access to appropriate specimens. It is the consequences of accepting them as primitive that are startling: the tachinoids are not recognizable because they possess distinctive characters derived from a common ancestor; they are distinct, recognizable and definable on the basis of characters which developed along innumerable parallel and convergent paths. The defining characters of the modern tachinoid families were not present in their ancestors.

Neophyto hirculus is the only species of its genus to show an almost complete set of primitive characters. Other species of *Neophyto* have a distinct vibrissal angle and a wider facial plate below the antennae, larger eyes, plumose aristae, etc., to varying degrees and in different combinations. Some closely related genera, like *Notochaeta,* show none of the primitive and every one of the derived extremes of the head characters of *Neophyto hirculus.* Clearly, the species of the *Neophyto* group have been moving away from the primitive conformation in parallel with each other almost without exception.

It does not matter whether *Neophyto* is considered as one genus or several; the parallelisms are not an artifact of nomenclature. The male genitalia are distinctive for the group, genus or otherwise, and the species are obviously related and distinct from other Sarcophaginae.

Other groups of Sarcophaginae do not include species with as many primitive features as *N. hirculus,* yet it is clear from other characters, including the male genitalia, that these groups did not evolve from within the *Neophyto* group. Consequently, the derived characters of these other groups must have developed independently of the similar derived features of the *Neophyto* group. Such rather exact parallelisms appear to have occurred throughout the Tachinoidea, as well as among the Muscoidea.

Melanomya seems to have paralleled *Neophyto,* with *M. cyrtoneurina* retaining the largest number of primitive features and *Melanomya bicolor* the fewest. In the remaining species of the genus the characters are usually intermediate in degree of development.

That there are so many parallelisms is considerably less astonishing if the characters are considered from a functional viewpoint. Apart from their frequent use of cryptic coloration, the tachinoid calyptrates normally avoid predators because they are fast and agile fliers. The majority of their conspicuous and apparently independent, derived features are not truly independent; they are functional aspects of an increased flight speed and agility.

In some cases the relationship is obvious: any insect that is going to fly fast must see well, hence the enlarged eyes. The association of the larger spiracles and calypters with improved flight powers is almost as obvious. A more powerful flight motor requires a higher rate of fuel consumption, which, in turn, necessitates an increased oxygen supply. Inasmuch as large spiracles impede gaseous exchange less than small spiracles, it is understandable that calyptrates with powerful flight motors should have larger spiracles.

The enlarged lower calypter appears to function as a windshield; it shields the halters from disruptive air jets, and, hence, is functionally related to flight. As would be expected, the calypters are best developed in the strongest fliers. They are also characteristic of strong-flying Diptera outside the Calyptratae (Tabanidae, Syrphidae).

Since modern calyptrates are typically active in the open in the daytime, they are continuously selected for speed and agility by visually-hunting predators all over the world (probably by birds foremost); only the fast and agile individuals escape. Given these conditions, it is not surprising to find abundant parallel evolution. The primitive representatives of *Neophyto, Melanomya,* or the Rhinophoridae were apparently shunted off from the mainstream of calyptrate evolution, evidently in some cases by their retiring habits.

Many less obvious correlates of enhanced flight power among tachinoids can only be understood from a historical perspective. The relevant historical hypotheses cannot be developed fully here, but are outlined in the following two paragraphs:

1) The tachinoid calyptrates originated early in and possibly before the Cretaceous. At this time they all resembled the archetype tachinoid as described (partially) above. The adults, like their ancestors, depended on the sugars in homopterous honeydew for their flight fuel. They avoided visually hunting predators by their small size (small enough to be unattractive prey to many predators), retiring habits (in woods or vegetation), or crepuscular to nocturnal habits.

2) When flowering plants underwent an adaptive radiation in the Cretaceous, many calyptrates developed longer proboscises as an adaptation for obtaining nectar. These early tachinoids did not abandon honeydew for nectar; in most cases the labellum remained as a functional device for obtaining dried honeydew from leaf surfaces, even as the proboscis lengthened. These flies thus gained the ability to capitalize on either honeydew or nectar, which increased the probability of the adults finding sugar fuels. This capability in turn enabled an increase in flight power with its higher fuel consumption (because the possibility of an early death due to fuel exhaustion had been offset by the higher probability of finding sugars).

The distinct vibrissal angle so characteristic of most calyptrates is not in itself functionally related to flight. It developed, however, as a consequence of morphological changes necessitated by a longer proboscis. During flight the proboscis is jack-knifed up into a cavity on the underside of the head called the "subcranial pit." When the proboscis lengthened in becoming better adapted for nectar use, the lower border of the head of most calyptrates also lengthened to create a longer subcranial pit for accommodating the longer segments of the proboscis. A simultaneous lengthening of the facial plate brought the hinge of the proboscis downward so that normal protrusion extended the proboscis ventrally rather than forward—which would be important for the continued use of homopterous honeydew. It is the simultaneous lengthening of the lower border of the head and the facial plate that created the prominent vibrissal angle.

The separation of the frontogenal sutures with the widening of the lower end of the facial plate reflects a lateral displacement of the origins of the rostral protractor muscles. (The sutures provide ridge-like braces for the operation of the protractors.) The lateral displacement appears to have facilitated the side-to-side movements of the proboscis, which are useful in reaching nectaries in awkward positions. This mobility is easily observed in the field, especially when the flies are obtaining nectar from umbelliferous plants. Such mobility is unnecessary in honeydew feeders that normally obtain dried honeydew from flat leaf surfaces.

The reduction of the genal groove was also not functional as such. The widening of the ventral edge of the facial plate brought about by the separation of the frontogenal sutures, and the enlargement of the eyes simply encroached upon much of the space formerly occupied by the genal groove. The loss of proclinate orbital bristles in males is also a result of the enlargement of the eyes of the male, which left little room for frontal plates between the eyes. The explanation for the lengthening of the third antennal segment and the development of a plumose arista is too complex to present here. These two antennal features are not immediately related to fast and agile flight.

Hennig (1966) correctly emphasized that primitive characters could not be trusted to define a monophyletic group. The preceding material indicates that derived characters cannot be trusted to define them either.

The Composition of the Rhinophoridae

Crosskey (1977) isolates *Rhinophora* and apparently related genera as a distinct tachinoid family, the Rhinophoridae. Subsequent authors seem inclined to follow that interpretation (McAlpine *et al.,* 1981; Rikhter, 1982), and this seems to be the best way to handle a difficult group of species.

I have found it most convenient to interpret this family as an intentionally practical rather than a natural taxon. In practice, the family is analagous to the Fungi Imperfecti, because it serves as a temporary holding place for primitive Tachinoidea whose systematic position has not yet been clarified. Such handling avoids many practical problems of classification, since the Rhinophoridae are easily characterized by their lack of the conventional defining characters of the other tachinoid families (or of major subgroups within them). Indeed, the family unavoidably functions in this fashion because of the many primitive genera about which we have so little information.

The history of the group exemplifies this usage. The family is built around a small group of genera closely resembling *Rhinophora.* Apparently these species are normally parasites of sowbugs (Crustacea: Isopoda), although the biologies of a number of them are still not known. *Cinochira atra* was formerly classified with them, because it lacked any of the defining characters of the other tachinoid families. However, *C. atra* is now known to parasitize lygaeid bugs (Michalk, 1938; Eyles, 1963). Apart from its possession of the primitive tachinoid characters, *Cinochira* does not show any particular affinity with *Rhinophora* or its close relatives. It more closely resembles certain phasiine tachinids, to which group it has now been removed.

The undescribed South American relative of *Neophyto* mentioned earlier was found among Rhinophoridae in the United States National Museum, and was presumed to belong to that group. Dissection of the male genitalia revealed that it was unequivocally a member of the *Neophyto* group of the Sarcophaginae.

The Systematic Position of *Melanomya*

The species of *Melanomya* formerly placed in the Rhinophoridae are another example of the practical use of the family, provided it can be shown that these species are not closely related to the sowbug parasites, but are more closely related to members of a major tachinoid family. Sufficient information has now been accumulated to show that this is the case.

The *Melanomya* in question (mostly subgenus *Angioneura)* resemble the sowbug parasites only in possessing the same primitive characters; there are no other characters to establish a positive link to the Rhinophoridae, *sensu stricto.* Instead, several *Melanomya,* and quite possibly all of them, are parasitic on snails. This habit is incongruous with the rhinophorid habit of parasitizing terrestrial isopods. Moreover, *Melanomya* lacks a coxopleural streak, which is a vestige of the original articulatory membrane between the meron of the coxa and the pleuron. The absence of the coxopleural streak thus represents a derived character-state. The genera I recognize as Rhinophoridae have a coxopleural streak, and the species that parasite sowbugs have a somewhat elongate hind coxa, which does not occur in *Melanomya.*

On the other hand, species of subgenus *Opsodexia* have male genitalia very similar to those of *Melinda ponti* Kurahashi (figured by Kurahashi, 1970). These genitalia are very similar to those of *Dexopollenia flava* (Aldrich) (figured by Kano & Shinonaga, 1968), and the aedeagi of *M. (Opsodexia)* are very similar to the aedeagus of *Melinda gentilis* Robineau-Desvoidy (figured by Kano & Shinonaga, 1968). The genitalia of these species closely resemble those of *Tricycleopsis paradoxa* Villeneuve (figured by Kurahashi, 1970), although the latter exhibits a few features more like those of *Melanomya (Angioneura)* spp.

All the species compared above are Asiatic representatives of the tribe Calliphorini, to which it might be assumed *Melanomya* should be assigned. Yet the Nearctic *Melanomya* very closely resemble the African *Obscuria,* which is treated as a synonym of *Phumosia* of an entirely different tribe, the Phumosiini, by Dear (1980). The male genitalia of certain *Melanomya* exhibit some significant similarities to those of *Helicobosca,* which in turn show some rather basic similarities to the Asiatic and Australian Ameniinae, which comprise still another group within the Calliphoridae. Although *Helicobosca* and the Ameniinae are superficially very different in external appearance from each other and from *Melanomya, Helicobosca* and certain Ameniinae have also been reared from snails (Séguy, 1941; Crosskey, 1965).

The Sarcophagidae are characterized by a bipouched, incubating uterus, and, so far as known, no sarcophagid has alphasetae, prothoracic pupal spiracular horns protruded through the puparial wall, or a preapical bristle on the anterior face of the midfemur. The few dissections I have made of *Melanomya* females indicate that they do not have a bipouched uterus; they do have alphasetae on the anterior margins of sterna 2-6, at least one species has prothoracic pupal horns protruded through the puparial wall, and the species have a preapical bristle on the anterior face of the midfemur. According to Thompson (1921), *M. pecchiolii* has a tubular uterus. These features exclude *Melanomya* from the Sarcophagidae.

The Calliphoridae appear to have some unknown basic feature which predisposes them to humid environments, while the Sarcophagidae have more often gravitated to xeric conditions. There are exceptions, of course, but these are apparently secondary issues. The basic difference between the families shows up consistently in the size attained by the thoracic spiracles. While the relationship of spiracle size to environmental moisture may not be obvious, the larger spiracles that enable a higher rate of oxygen uptake also permit a more rapid water loss. Water loss is a critical problem in xeric environments for animals as small as flies, and species that must live in xeric conditions cannot afford large spiracles.

The Calliphoridae have repeatedly developed very large posterior thoracic spiracles that intrude forward into the hind margin of the meron. The hind margin of the meron becomes concave forwards because of the large spiracle. Sarcophagidae do not develop such large spiracles, and never seem to have the hind margin of the meron concave, even when their spiracles are large for the family. While the relatively primitive *Melanomya* species have small spiracles, the spiracles of some species, like *M. bicolor*, are somewhat enlarged, and these intrude forward into the meron (Fig. 5) in typical calliphorid form.

From the standpoint of practical identifications, the Nearctic members of the *Melanomya* group may be easily separated from the Sarcophagidae. The Nearctic species of the latter have no subscutellum whatsoever (Fig. 4), and veins R_{4+5} and M end in the costa distinctly anterior to the extreme wing tip. All the Nearctic *Melanomya* have a small subscutellum, as in Fig. 3, and veins R_{4+5} and M end in or a little behind the extreme wing tip, as in Fig. 7.

From the Tachinidae, *Melanomya* is separated by the snail-parasitizing habit of so many of its species. All known Tachinidae parasitize insects or, rarely, chilopods. The practical identifications of Nearctic species is simple, because nearly all Nearctic Tachinidae have a very well-developed subscutellum (Fig. 2). The rarely collected species that do not have a well-developed subscutellum do not have an angularly bent M. Vein M courses to the costa in a nearly straight or slightly curved line in *Eugymnogaster*, or it fades out entirely before reaching the margin of the wing *(Bezzimyia)*.

It is quite possible that genuine Rhinophoridae are not native to the New World. The two Nearctic species, *Melanophora roralis* (Linnaeus) and *Phyto discrepans* Pandellé, also occur in Europe, and they could easily have been introduced into North America with their sowbug hosts in early shipping ballast. *Phyto discrepans* has been recorded only from Newfoundland, Canada. In both species vein M ends in R_{4+5} a short distance before the costa, and R_{4+5} ends in the costa anterior to the extreme wing tip. These characters readily distinguish the Nearctic Rhinophoridae from *Melanomya*.

Two conclusions may be drawn from the preceding data: first, the species of *Melanomya* show relationships to a rather wide variety of Calliphoridae, but no identifiable relationship to the Rhinophoridae, Sarcophagidae or Tachinidae; second, the relationships of *Melanomya* within the Calliphoridae are exceedingly obscure (simply because relationships within the Calliphoridae are exceedingly obscure).

The decision to place *Melanomya* in the Melanomyini, Polleniinae (Hall, 1965) was an editorial decision; the genus had to be put somewhere, and the tribal name was available. *Melanodexia* (Polleniinae) is the closest of any of the Nearctic Calliphoridae to *Melanomya* in habitus, but *Melanodexia* differs from *Melanomya* in having a coxopleural streak and a "bridge" or low carina between the bases of the antennae. These characters and the male genitalia (figured by Hall, 1948) indicate that *Melanodexia* is correctly associated with *Pollenia*. The similarities between *Melanodexia* and *Melanomya* appear to be only the result of their common possession of primitive features. It is perhaps best to regard *Melanomya* and its relatives as calliphorids of uncertain position until the supra-generic classification of the Calliphoridae can be clarified.

The Composition of *Melanomya*

Conceivably, any of three reasons might dictate that *Melanomya* should be treated as more than one genus:

1) A species could be removed from *Melanomya* if it were shown that it is not in fact related to the other species of the genus. Normally, to make such a judgment requires demonstrating that the affinities of the removed species lie elsewhere.

2) An aberrant species not conveniently keyed with the others might be removed for purely practical reasons.

3) In cases where the number of species is excessively large it may be more convenient to split the genus, provided suitable differentiating characters could be found.

Obviously, *Melanomya* is not excessively large, even when every possible Old World species is included. Nor does *Melanomya* include such aberrant species that it cannot be conveniently addressed as a single genus. The opposite is true; the species are easily keyed out as a group. Moreover, the included species seem obviously related to one another on the basis of biology, general habitus, and other characters, such as the absence of the coxopleural streak. At first sight the male genitalia may suggest distinct groups, but the unusual curve in the basiphallus and base of the gonopods of subgenus *Angioneura* is represented in only a lesser degree in various species of subgenus *Opsodexia*. In all species the dorsolateral processes of the aedeagus are short and appressed to the main body of the distiphallus. This is not illustrated in the plates except for Figs. 9 and 39. The more typical calliphorid aedeagus is shown by figures 32 and 33.

Very little is known about *Glutoxys* and *Pseudopsodexia*. Their relationship to *Melanomya* cannot be assessed yet, and for this reason they have been separated primarily for reasons of convenience.

Crosskey (1977) regarded the plumose arista, the pilose dorsal proepisternum, the pilose prosternum, and the general appearance of the head as distinguishing *Opsodexia* from *Melanomya* and *Angioneura*, and these characters were interpreted as indicating that *Opsodexia* was more closely related to the Calliphoridae.

Crosskey's information was apparently based on specimens of *M. bicolor. M. (Opsodexia) grisea* and *M. (O.) nox* do not have setae on the dorsal proepisternum. In *M. grisea* the prosternum is sometimes setulate, sometimes not. Both *M. grisea* and *nox* are brownish-black flies more similar in habitus to members of subgenus *Angioneura* than to *M. bicolor* or any other Calliphoridae.

The species of subgenus *Opsodexia* have a plumose arista, and *M. bicolor* rather closely resembles certain smaller species of the African *Phumosia,* but this does not mean that *M. bicolor* is closer to *Phumosia* than to the species of *Melanomya.* The male genitalia and similarities listed in the descriptions above clearly indicate the Nearctic *Opsodexia* species belong together, and some of them are close to subgenus *Angioneura. Phumosia* is also distinguished by an unusual character: the katatergite is haired. However, it is possible that *Melanomya* and *Phumosia* are related genera, but, if so, *Melanomya* as a whole is related to *Phumosia.*

The plumose arista has arisen independently in every calyptrate family. It is highly polyphyletic in the Sarcophagidae, and, apparently, also in the Calliphoridae. In subgenus *Angioneura* alone the arista varies from bare (*Melanomya cyrtoneurina*) to short plumose (*M. flavipennis*). In *M. (Eggisops) pecchiolii* the arista is only short plumose for about half its length. The same is true for *Helicobosca distinguenda* Villeneuve (Calliphoridae), and *M. nox* has an arista that is not nearly so long-plumose as that of *M. bicolor;* it is medium to short-plumose for about two-thirds its length. Séguy (1928) records *Metallea* and *Rhynchomyia* (Calliphoridae, Rhiniinae) as having bare aristae. The fully plumose arista can not be regarded as a distinguishing feature of the Calliphoridae; it is polyphyletic in origin, and a scattering of species have retained an arista that is less than fully plumose.

Crosskey (1977) regarded the small size and character of the vestiture of the posterior thoracic spiracle as especially important in delimiting the Rhinophoridae. Although *Melanomya nana* has been classified consistently with the Rhinophoridae, my specimens (a male and a female from England) do not fit the rhinophorid spiracular pattern. Their posterior thoracic spiracle is elongated and slanted forward, and the anterior fringing hair flap is much better developed than the posterior. This pattern occurs in *M. (Eggisops) pecchiolii, M. (Opsodexia) nox* and *M. (Opsodexia) grisea,* and it is developed to an extreme in the African *Phumosia.* I have not seen this pattern anywhere except in these and certain other Calliphoridae.

Melanomya (Opsodexia) bicolor has a more typical calliphorid spiracular pattern, and only *M. (Angioneura) cyrtoneurina, M. obscura* and *M. flavescens* seem to match the rhinophorid pattern (*M. ordinaria* is rather intermediate). *Neophyto hirculus* has the rhinophorid spiracular pattern, and keys to that family in Crosskey's key (1977), but it is a primitive sarcophagid (Sarcophaginae). *Macronychia* (Sarcophagidae, Miltogramminae) also has a rhinophorid spiracular pattern, and shows many primitive characters otherwise. I do not see how it is possible to explain the small spiracles and reduced vestiture except as primitive retentions in relict species that occur in every tachinoid family. The larger spiracles have had parallel origins both within and without the *Melanomya* group.

Crosskey (1977) mentions that European *Melanomya nana* have an occasional adventitious hair on the prosternum. This is more characteristic of *Melanomya* than any Rhinophoridae. It does not appear that any species included in *Melanomya* can be shown to be more closely related to species outside the genus than to other included species. (It is a "natural" genus.)

If we grant that the *Melanomya* species belong together, a second consideration still needs to be addressed. Should the species be included in one or more than one genus? This is a practical decision, but there are many reasons for maintaining a conservative classification with fewer generic names. *Melanomya* includes only a few species. Non-specialists obviously prefer the fewer names of a conservative classification (as a perusal of *Biological Abstracts* for the past 25 years shows conclusively for the use of *Sarcophaga, sens. lat.*). The fewer generic names of a conservative classification makes information access through the indexing journals a much simpler matter. Information access with the plethora of names that results from the use of restricted genera is a nightmare. Moreover, we do not have so much to say about these flies that we need so many names to say it with.

Statements to the effect that one genus is different from another subtly imply, erroneously, a certain objectivity of judgment. Such genera are also alike. The level at which generic limits are set is arbitrary and a matter of convenience, as long as they are set between family and species levels. As already indicated, it is convenient for several reasons to treat the *Melanomya* species as one genus. While this may be regarded a minor matter for the present set of species, it is not a minor matter for calyptrate families with hundreds and thousands of species.

This is not to claim that *Melanomya* is one genus in an objective sense. It is merely an assertion that the available data do not support another treatment, especially from a practical viewpoint. There are so many loose ends in the classification of the Calliphoridae, particularly in the Old World, that it would be hazardous to predict the outcome of further study. That is a matter that would best be taken up by taxonomists who have ready access to Old World material.

LITERATURE CITED

Adams, C. F. 1941. A preliminary list of muscoid flies in Missouri. Missouri Acad. Sci., Proc. 6: 73-74.

Aldrich, J. M. 1929. New genera and species of muscoid flies. U. S. Natl. Mus., Proc. 76(Art. 15): 1-13.

Audcent, H. 1942. A preliminary list of the hosts of some British Tachinidae (Dipt.). Soc. Brit. Entomol., Trans. 8: 1-42.

Bezzi, M., and P. Stein. 1907. Cyclorrhapha Schizophora: Schizometopa (pp. 190-749). *In* Becker, T., M. Bezzi, K. Kertesz, and P. Stein (eds.). Katalog der paläarktischen Dipteren, Vol. 3. Budapest, Hódmezövásárhely, Druck von G. Wesselényi. 828pp.

Brauer, F., and J. E. v. Bergenstamm. 1889. Die Zweiflügler des Kaiserlichen Museums zu Wien. Part I. K. Akad. der Wiss. Wien, Math.-Nat. Kl., Denkschr. 56: 69-180.

______. 1893. Die Zweiflügler des Kaiserlichen Museums zu Wien. Part III. K. Akad. der Wiss. Wien, Math.-Nat. Kl., Denkschr. 160-0: 89-240.

Brown, A. W. A. 1934. A contribution to the insect fauna of Timagami. Canad. Entomol. 66: 206-211, 220-231, 242-252, 261-267.

Coquillett, D. W. 1899. New genera and species of Dexiidae. N. Y. Entomol. Soc., Jour. 7: 218-222.

______. 1902. New Diptera from North America. U. S. Natl. Mus., Proc. 25: 83-126.

Crosskey, R. W. 1965. A systematic revision of the Ameniinae (Diptera: Calliphoridae). British Museum (Nat. Hist.) Entomol. Bul. 16: 33-140.

______. 1977. A review of the Rhinophoridae (Diptera) and a revision of the Afrotropical species. British Museum (Nat. Hist.) Entomol. Bul. 36(1): 1-66.

Curran, C. H. 1934. The families and genera of North American Diptera. New York, N. Y. ; Published by the author. 512pp.

Dear, J. P. 1980. Family Sarcophagidae (pp. 801-818). *In* Crosskey, R. W., B. H. Cogan, P. Freeman, A. C. Pont, K. G. V. Smith, and H. Oldroyd. Catalogue of the Diptera of the Afrotropical Region. London; British Museum (Natural History). 1437pp.

Dodge, H. R. 1965. The Sarcophagidae (Diptera) of the West Indies. II. Jamaica. Entomol. Soc. Amer., Ann. 58(4): 497-517.

Downes, W. L. Jr. 1955. Notes on the morphology and classification of the Sarcophagidae and other calyptrates (Diptera). Iowa Acad. Sci., Proc. 62: 514-538.

______. 1958. The Nearctic Miltogramminae (Diptera, Sarcophagidae) and certain allies. Ames, Iowa; Iowa State University, Ph. D. Thesis. 307 pp.

______. 1965. Tribe Melanomyini (pp. 932-933). *In* Stone, A., C. W. Sabrosky, W. W. Wirth, R. H. Foote, and J. R. Coulson. A Catalog of the Diptera of America north of Mexico. U. S. Dept. Agric. Handbook 276: iv+1696pp.

Emden, F. I. van. 1954. Diptera: Cyclorrhapha Calyptrata (I), Section (a). Tachinidae and Calliphoridae. Handbooks for the Identification of British Insects 10(Part 4a): 1-133.

Eyles, A. C. 1963. Some notes on natural enemies of Lygaeidae (Hem.). Soc. Brit. Entomol., Trans. 98: 226-227.

Griffiths, G. C. D. 1972. The phylogenetic classification of Diptera Cyclorrhapha. The Hague; Dr. W. Junk N. N. 340pp.

Hall, D. G. 1948. The blowflies of North America. (Washington, D. C.); Thomas Say Foundation (Entomological Society of America). (v)+477pp.

______. 1965. Family Calliphoridae (pp. 922-932). *In* Stone, A. ; C. W. Sabrosky, W. W. Wirth, R. H. Foote, and J. R. Coulson. A Catalog of the Diptera of America north of Mexico. U. S. Dept. Agric. Handbook 276: iv+1696pp.

Hallock, H. C. 1937. A list of the Sarcophagidae of New York (Diptera). Entomol. News 48: 258-262.

______. 1940. The Sarcophaginae and their relatives in New York, Part I. N. Y. Entomol. Soc., Jour. 48: 127-153.

Hendrickson, G. O. 1930. Studies on the insect fauna of Iowa prairies. Iowa State Col. Jour. Sci. 4: 49-179.

Hennig, W. 1966. Phylogenetic systematics. Urbana, Ill. ; Univ. of Illinois Press. 263pp.

Herting, B. 1961. 64e. Rhinophorinae (iii+36pp.). *In* E. Lindner. Die Fliegen der Palaearktischen Region. Lief. 216. Stuttgart; E. Schweizerbart'sche Verlagsbuchhandlung (Nagele u. Obermiller).

Johnson, C. W. 1925. Fauna of New England. 15. List of the Diptera or two-winged flies. Boston Soc. nat. Hist., Occas. Pap. 7: 1-326.

Kano, R., and S. Shinonaga. 1968. Calliphoridae (Insecta: Diptera). (ix+181pp. + 23 Pls.). *In* Fauna Japonica. Tokyo, Japan; Biogeographical Society of Japan.

Knowlton, G. F. 1936. Some Utah flesh flies. Utah Acad. Sci., Arts and Letters, Proc. 13: 237-239.

Kurahashi, H. 1970. Tribe Calliphorini from Australian and Oriental Regions, I. *Melinda*-group (Diptera: Calliphoridae). Pacific Insects 12(3): 519-542.

Lopes, H. de S. 1969. Family Sarcophagidae. (vol. 103: 1-88). *In* A catalog of the Diptera of the Americas south of the United States. São Paulo; Departmento de Zoologia, Secretaria da Agricultura.

_____. 1973. *Glutoxys* Aldrich, 1929, a typical genus of Calliphoridae (Diptera). Acad. Brasil. Cienc., An. 45(2): 277-278.

McAlpine, J. F., B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood. 1981. Manual of Nearctic Diptera. Vol. 1. Research Branch, Agriculture Canada, Monograph 27:vi+674pp.

Meigen, J. W. 1826. Systematische Beschreibung der bekannten europäischen zweiflügeligen Insekten. Vol. 5. Hamm; Schultz'schen Buchhandlung. xii+412pp. + Pls. 42-54.

Michalk, O. 1938. Neue Entoparasiten der palaearktischen Heteropteren. (Driter Beitrag zur Kenntnis der Wanzenschmarotzer). Arb. ü. Physiol. Angew. Entomol. aus Berlin-Dahlem 5: 255-260.

Neck, R. W., and H. de S. Lopes. 1973. On some North American Sarcophagidae and Calliphoridae (Diptera) reared from Gastropoda. Rev. Brasil. de Biol. 33(2): 183-192.

Ouellet, J. 1941. Additions au catalogue des diptères du Quebec. Nat. Canad. 68: 121-141.

Pringle, J. W. S. 1948. The gyroscopic mechanism of the halteres of Diptera. Roy. Soc. London, Phil. Trans., Ser. B 233: 247-284 + Pl. 23.

Reinhard, H. J. 1929. Notes on the muscoid flies of the genera *Opelousia* and *Opsodexia* with the description of three new species. U. S. Natl. Mus., Proc. 76(Art. 20): 1-9.

_____. 1945. New genera and species of muscoid flies. Kansas Entomol. Soc., Jour. 18: 6-77.

Rikhter, V. A. 1980. Some plesiomorphous characters of male genitalia in the family Tachinidae (Diptera). Entomol. Obozr. 59(4): 925-934. (English transl., Entomol. Rev. 59: 162-170, 1982).

Rondani, C. 1856. Dipterologiae Italicae. Vol. I. Parma; Stocchi. 228pp. (Facs. ed., Berlin; W. Junk, 1914).

_____. 1862. Dipterologiae Italicae. Vol. 5. Parma; Stocchi. 239pp. (Facs. ed., Berlin, W. Junk, 1914).

Schiner, I. R. 1862. H. 6/7. (pp. 441-656). *In* L. Redtenbacher and I. R. Schiner. Fauna Austriaca, Vol. 1. Die Fliegen (Diptera) (by Schiner). Wien; Gerold. lxxx+674pp. + 2 Pls.

Scudder, S. H. 1882. Nomenclator zoologicus. U. S. Natl. Mus., Bul. 19: i-xxi; Part I, 1-376; Part II, 1-340.

Séguy, E. 1928. Études sur les mouches parasites. Tome I. Conopides, Oestrides et Calliphorines de l'Europe occidentale. Encyclopédie Entomologique, Ser. A 9: 1-251.

_____. 1941. Études sur les mouches parasites. Tome II. Calliphorides. Enclyclopédie Entomologique, Ser. A 21: 1-438.

Thompson, W. R. 1921. Contribution a la connaissance des formes larvaires des Sarcophagides. I. *Engyzops Pecchiolii* Rond. Soc. Entomol. France, Bul. 1921: 27-31.

Townsend, C. H. T. 1915. Proposal of new muscoid genera for old species. Biol. Soc. Wash., Proc. 28: 19-23.

_____. 1919. New genera and species of muscoid flies. U. S. Nat'l. Mus., Proc. 56: 541-592.

_____. 1935a. New muscoid genera, mainly from the Neotropical Region. Rev. Entomol. 5: 68-74.

_____. 1935b. Manual of myiology. Part. II. Muscoid classification and habits. Itaquaquecetuba, São Paulo, Brazil; Charles Townsend and Filhos. 296pp. + 7 Pls.

_____. 1938. Manual of myiology. Part VI. Muscoid generic diagnoses and data. Stephanostomatini to Moriniini. Itaquaquecetuba, São Paulo, Brazil; Charles Townsend and Filhos. 309pp.

Villeneuve, J. 1924. Contribution à la classification des "Tachinidae" paléarctiques. Ann. Sci. Nat.-Zool. (Ser. 10) 7:5-39.

West, L. S. 1925. New Phasiidae and Tachinidae from New York State. New York Entomol. Soc., Jour. 33: 121-135.

_____. 1928. Family Dexiidae (pp. 821-823). *In* Leonard, M. D. A list of the insects of New York. Cornell Univ. Agric. Expt. Sta. Mem. 101: 1121pp. + 1 map.

Wray, D. L. 1950 Second supplement to the insects of North Carolina. Raleigh, North Carolina; No. Carolina Department of Agriculture. 59pp.

Zetterstedt, J. W. 1859. Diptera Scandinaviae. Disposita et descripta, Vol. 13, Sup. 4. Lundae. pp. v-xvi + 4943-6190.

PLATE I

Miscellaneous Taxonomic Features

1 – *Melanomya obscura,* head of male (width 1.6 mm).

2 – *Allophora* sp., scutellum and mesopostnotum, showing a well-developed subscutellum, profile view.

3 – *Melanomya obscura,* scutellum and mesopostnotum, showing weakly developed subscutellum, profile view.

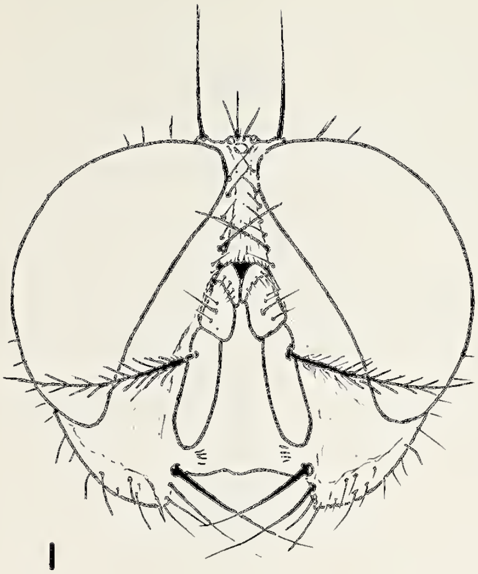
4 – *Sarcophaga sinuata* Meigen, scutellum and mesopostnotum, showing no differentiated subscutellum, profile view.

5 – *Melanomya bicolor,* meron, posterior thoracic spiracle, and adjacent structures on side of thorax.

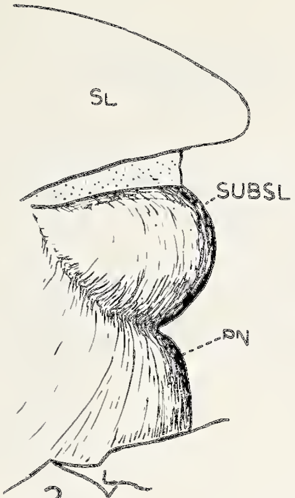
6 – *Melanomya obscura,* mesoanepisternum (mesopleuron).

7 – *Melanomya obscura,* wing (length 4.5 mm).

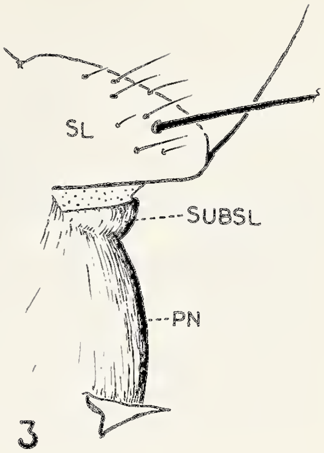
Abbreviations: AES2, mesoanepisternum; NPLS, notopleural bristles (sockets); PN, mesopostnotum; SL, scutellum; SP1, anterior thoracic spiracle; SP2, posterior thoracic spiracle; SUBSL, subscutellum (the "postscutellum").



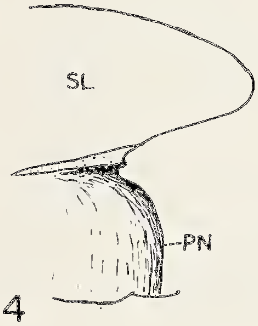
1


SL
SUBSL
PN

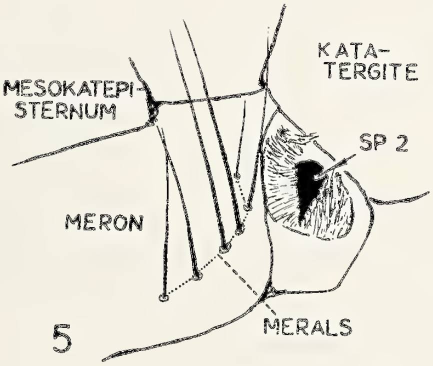
2


SL
SUBSL
PN

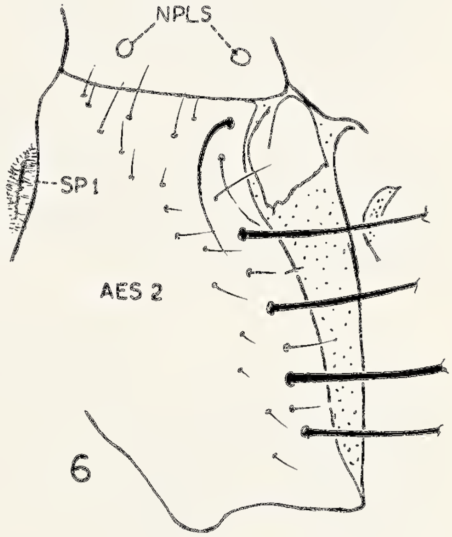
3


SL
PN

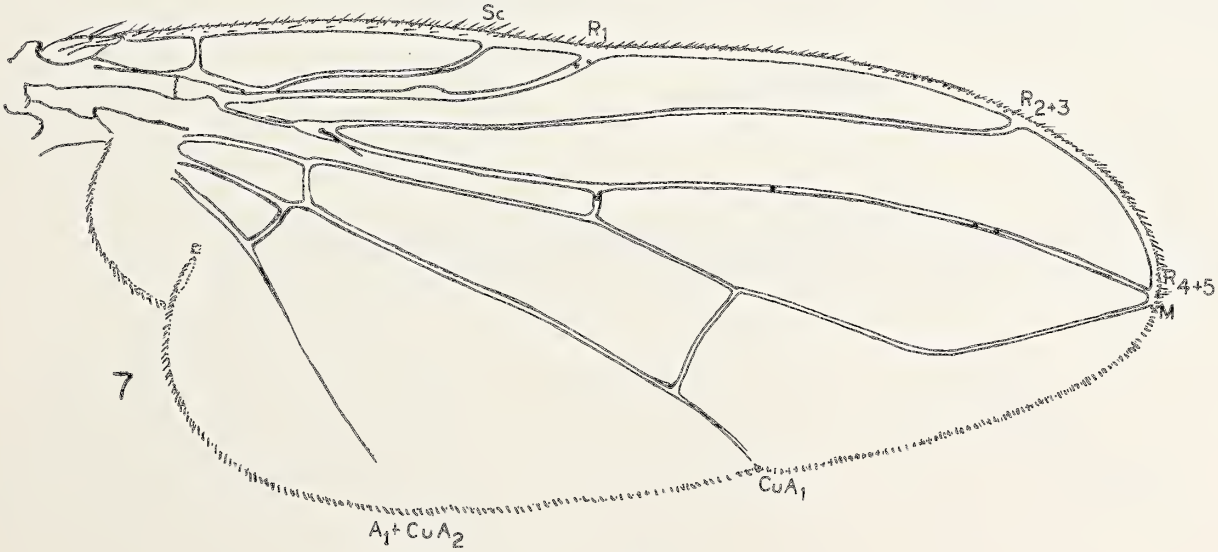
4


KATA-
TERGITE
MESOKATEPI-
STERNUM
SP 2
MERON
MERALS

5


NPLS
SP1
AES 2

6


Sc
R_1
R_{2+3}
R_{4+5}
M
CuA_1
A_1+CuA_2

7

PLATE II

Melanomya (Angioneura) mitis

8 – Aedeagus and pump sclerite, lateral view.

9 – Aedeagus, posterior view of ventral tip.

10 – Gonopod (left "finger" and paramere (shaded)), lateral view.

11 – Surstylus and cercus, lateral view.

12 – Surstyli and cerci, posterior view.

Melanomya (Angioneura) crytoneurina

13 – Aedeagus, lateral view.

14 – Gonopod and paramere, lateral view.

15 – Surstylus and cercus, lateral view.

Glutoxys elegans

16 – Gonopod and paramere, lateral view.

17 – Surstylus and cercus, lateral view.

18 – Aedeagus, lateral view.

Melanomya (Angioneura) obscura

19 – Detail of anterolateral corner of sternum from Fig. 20, showing alphaseta (presumably a *sensillum trichodeum*).

20 – Fifth abdominal sternum, showing alphasetae at anterior margin.

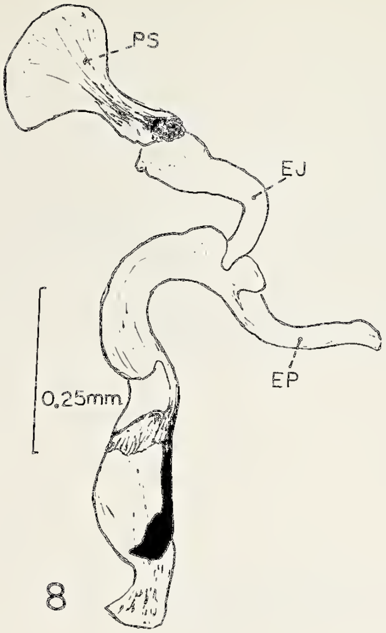
Melanomya (Opsodexia) bicolor

21 – Anterior face of tip of midfemur, showing a differentiated preapical seta.

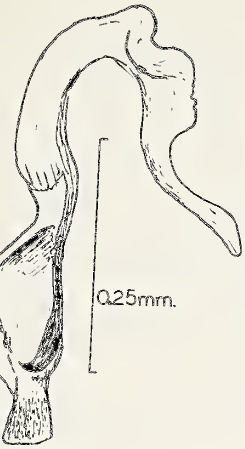
Melanodexia sp.

22 – Antennal area of face.

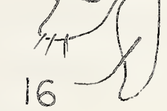
Abbreviations: AN1, AN2, AN3, first, second and third antennal segments, respectively; CE, cercus; EJ, ejaculatory duct; EP, epiphallus; FE2, midfemur; FL, lunule; GN, gonopod; PM, paramere; PS, pump sclerite; SR, surstylus; TI2, midtibia.



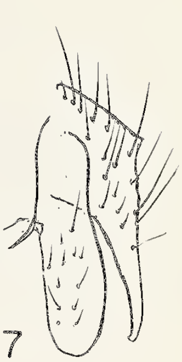
8



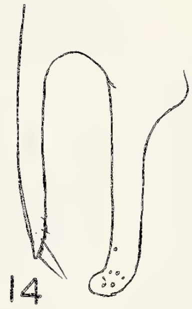
13



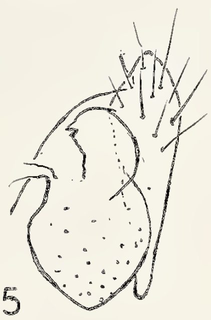
16



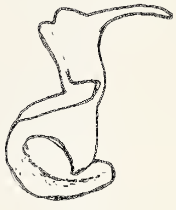
17



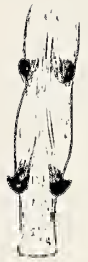
14



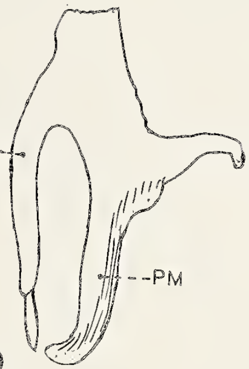
15



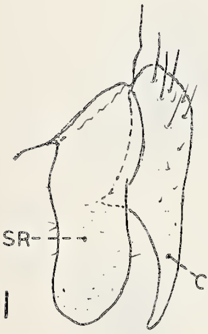
18



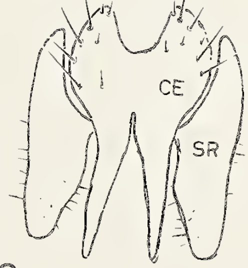
9



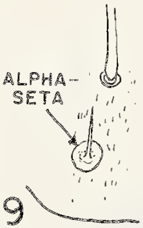
10



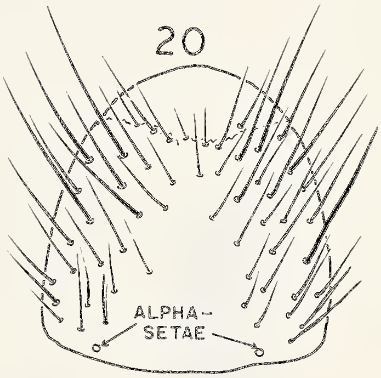
11

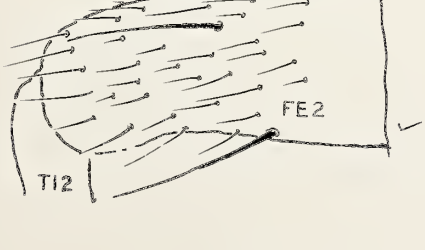


12

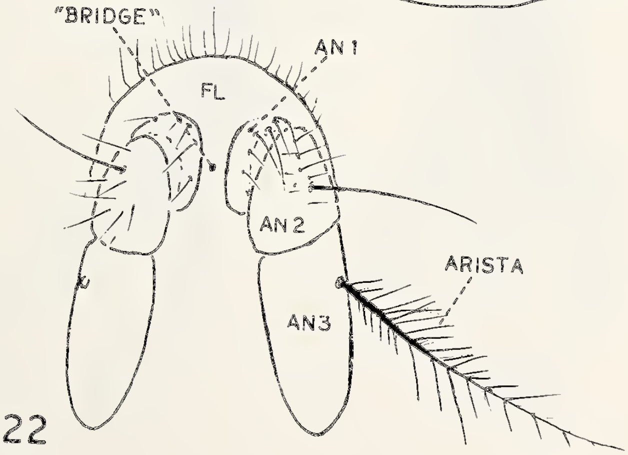


19





21



22

PLATE III

23 – *Melanomya flavescens,* scutellum.

24 – *Melanomya bicolor,* scutellum.

25 – *Glutoxys elegans,* mesoanepisternum (shaded).

26 – *Melanomya flavescens,* spermathecae, linings of spermathecal ducts and accessory glands.

Pseudopsodexia cruciata (Holotype)

27 – Postgonite, lateral view.

28 – Cerci and surstyli, posterior view (left cercus broken).

29 – Aedeagus, lateral view (broken; a portion of the shaft of the aedeagus may be missing).

30 – Cercus and paralobe, lateral view (cercal setae not drawn).

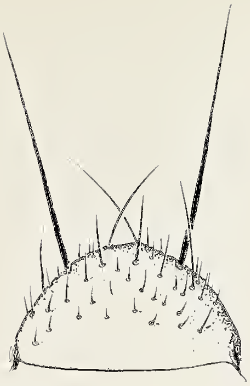
31 – Gonopod, lateral view.

Morinia ?melanoptera

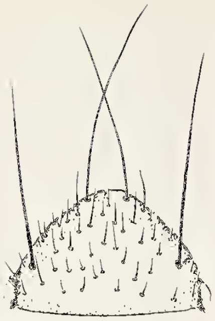
32 – Aedeagus, lateral view.

33 – Aedeagus, posterior view.

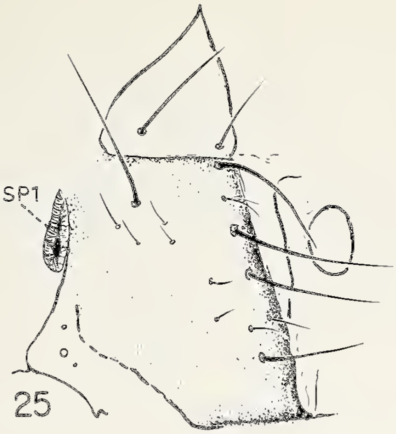
Abbreviation: SP1, anterior thoracic spiracle.



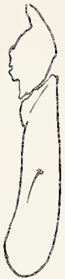
23



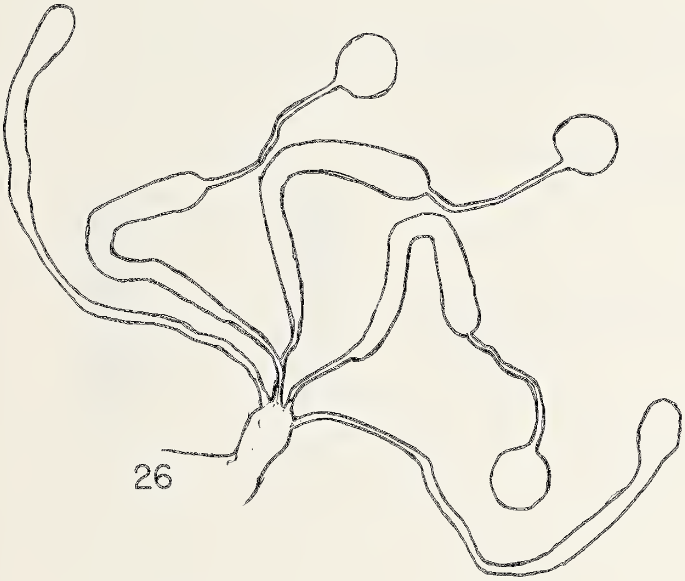
24



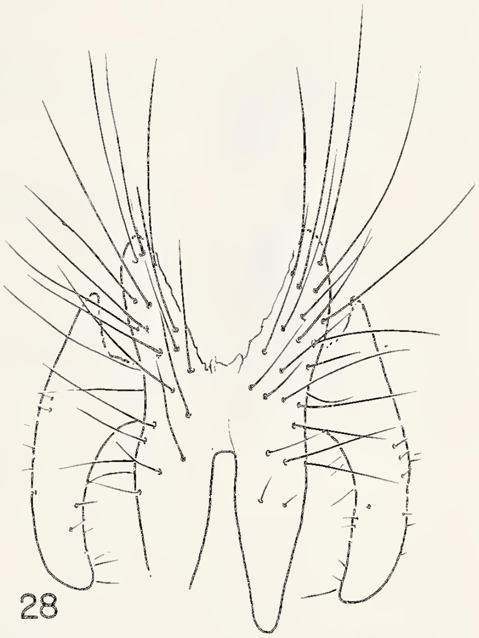
25



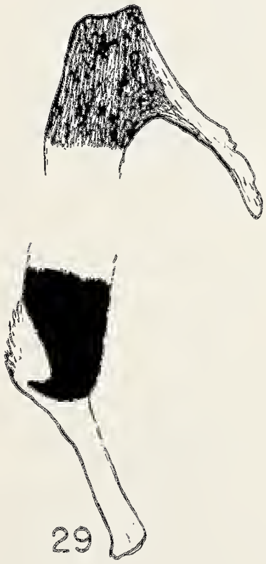
27



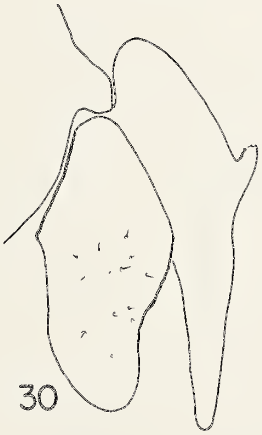
26



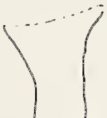
28



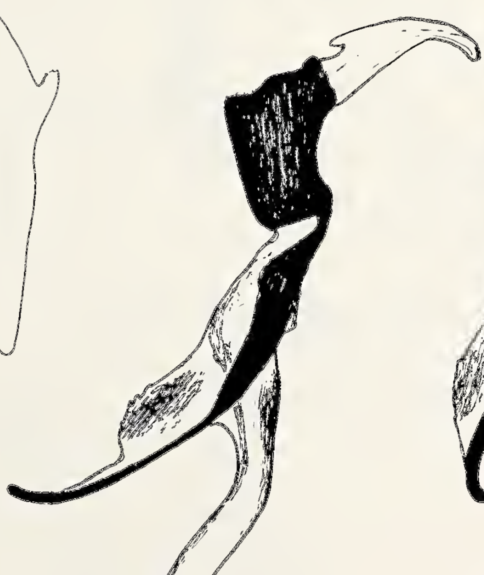
29



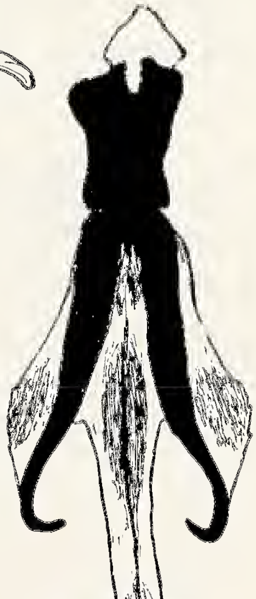
30



31



32



33

PLATE IV

Melanomya (Melanomya) nana

34 – Cerci and surstyli, posterior view.

35 – Cercus and surstylus, lateral view.

36 – Paramere, lateral view.

37 – Hypandrium with gonopod, lateral view.

38 – Aedeagus, lateral view.

39 – Aedeagus, posterior view.

40 – Tenth sternites (shaded) with posterolateral arms of hypandrium showing at bottom of figure, ventral view.

Melanomya (Eggisops) pecchiolii

41 – Cerci and surstyli, posterior view.

42 – Cercus and surstylus, lateral view.

43 – Hypandrium with gonopod, paramere and basal apodeme, lateral view.

44 – Aedeagus, lateral view.

Melanomya (Opsodexia) bicolor

45 – Cerci and surstyli, posterior view.

46 – Cercus and surstylus, lateral view.

47 – Aedeagus, lateral view.

48 – Hypandrium, gonopod and paramere, lateral view.

49 – Pump sclerite.

Melanomya (Opsodexia) nox, n. sp.

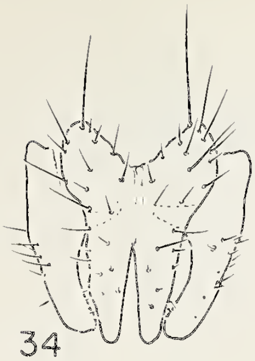
50 – Cerci and surstyli, posterior view.

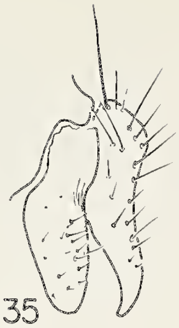
51 – Cercus and surstylus, lateral view.

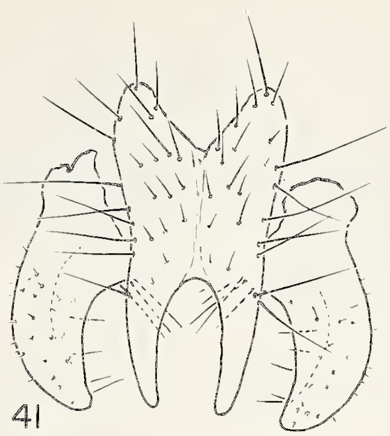
52 – Aedeagus, lateral view.

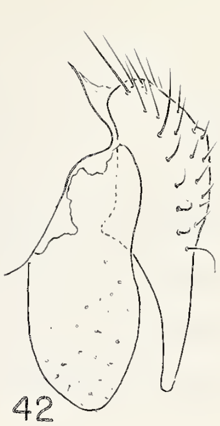
53 – Hypandrium, gonopod and paramere, lateral view.

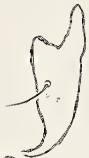
Abbreviations: BA, basal apodeme; GN, gonopod; HP, hypandrium ("ninth sternum").

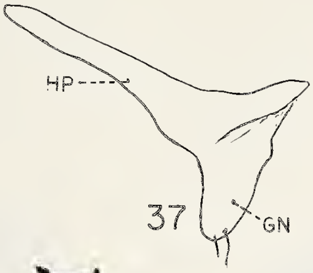

34


35

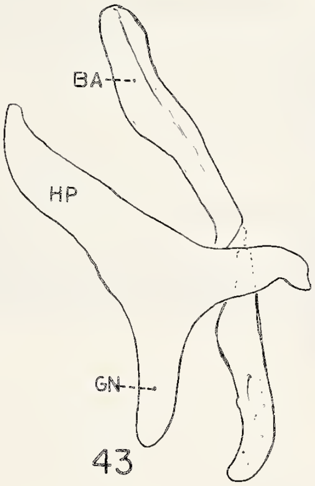

41


42

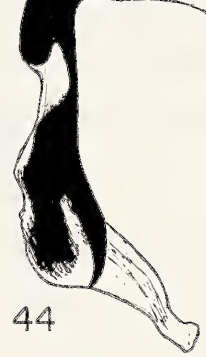

36

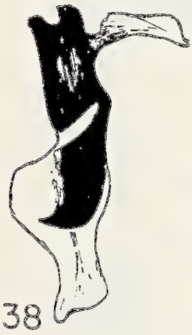


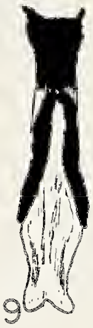
37

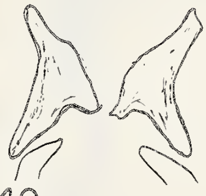


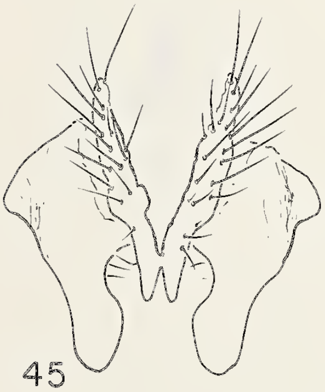
43

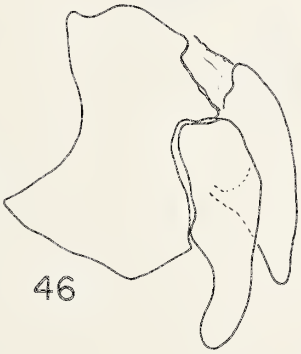

44

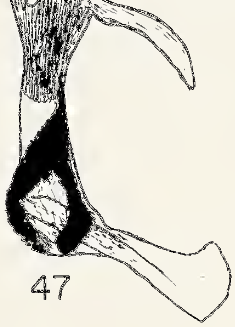

38

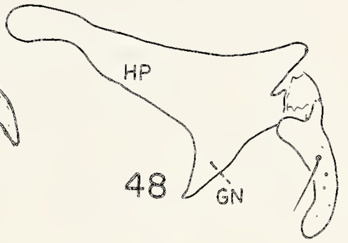

39


40

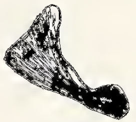

45

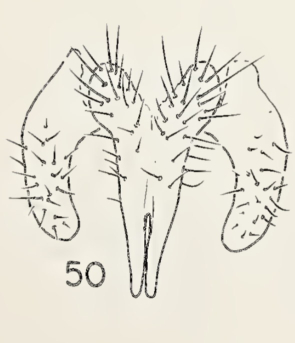

46

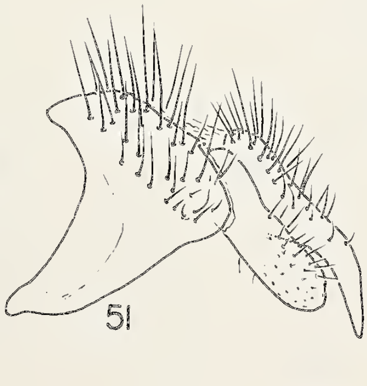

47

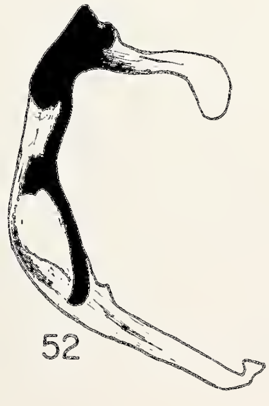


48


49


50


51


52

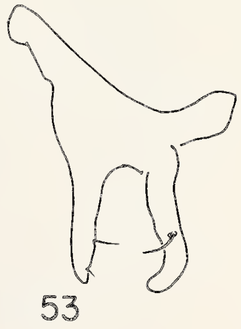

53

PLATE V

Melanomya (Angioneura) ordinaria

54 – Cerci and surstyli, posterior view.
55 – Cercus and surstylus, lateral view.
56 – Aedeagus, lateral view.
57 – Gonopod and paramere, lateral view.

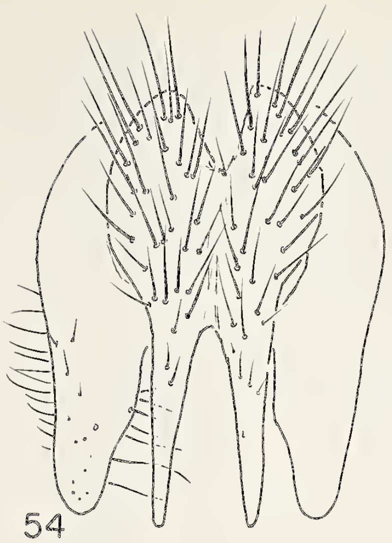
Melanomya (Opsodexia) grisea

58 – Cerci and surstyli, posterior view.
59 – Cercus and surstylus, lateral view.
60 – Aedeagus, lateral view.
61 – Hypandrium, gonopod and paramere, lateral view.

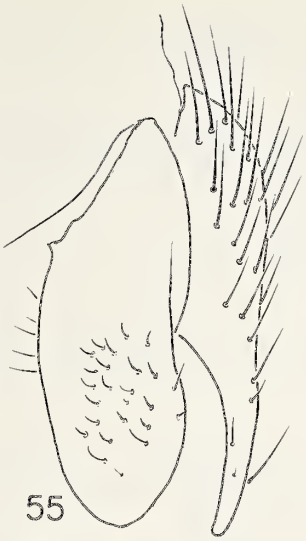
Melanomya (Opsodexia) flavipennis (Holotype)

62 – Aedeagus, lateral view.
63 – Paramere, lateral view.
64 – Gonopod, lateral view.
65 – Cerci and surstyli, posterior view.
66 – Cercus and surstylus, lateral view.

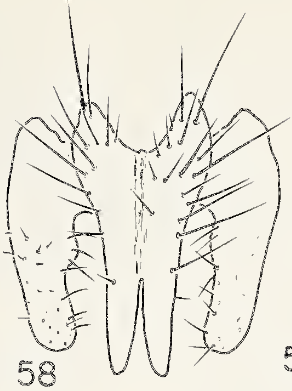
Abbreviation: HP, hypandrium ("ninth sternum").



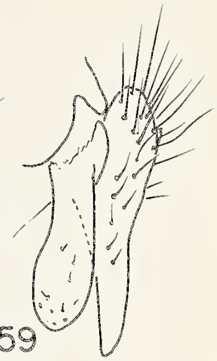
54



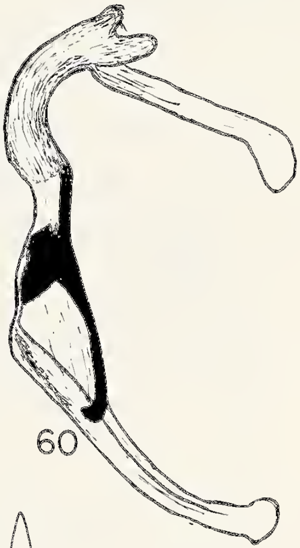
55



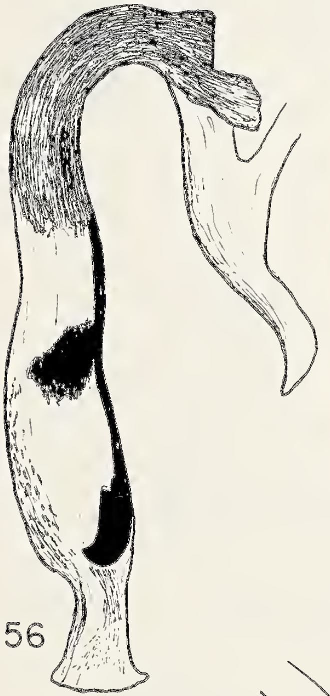
58



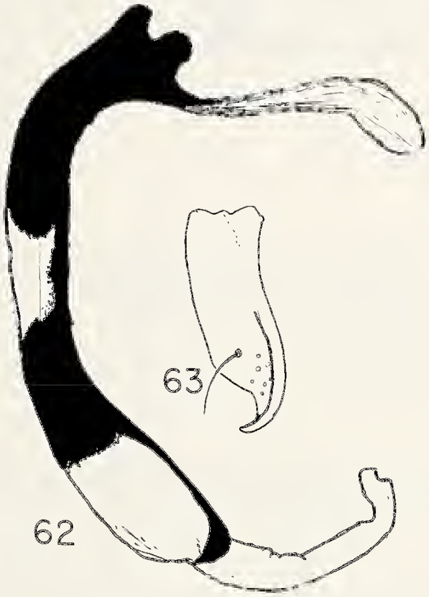
59



60

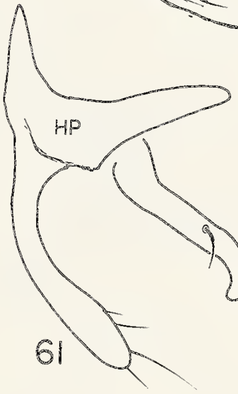


56

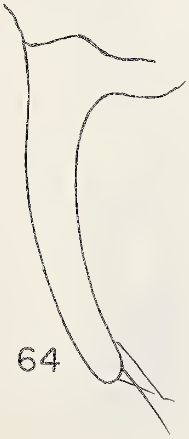


62

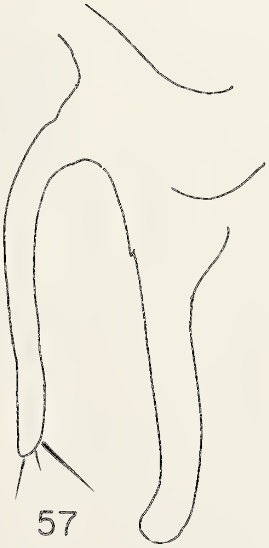
63



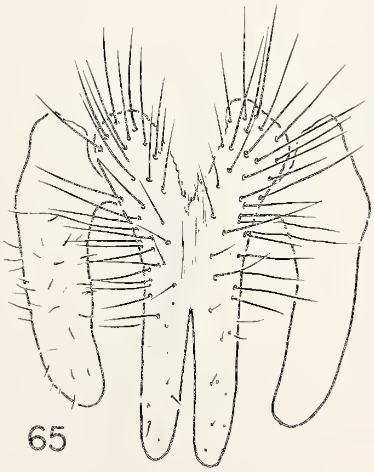
61



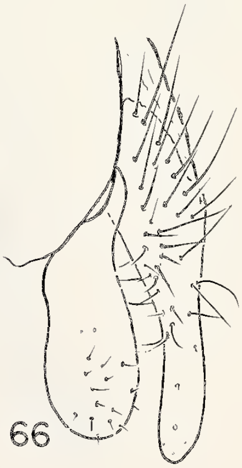
64



57



65



66

PLATE VI

Melanomya (Angioneura) obscura

67 – Cerci and surstyli, posterior view.

68 – Cercus and surstylus, lateral view.

69 – Aedeagus, lateral view.

70 – Hypandrium with gonopod, paramere, and basal apodeme, lateral view.

71 – Pump sclerite.

Melanomya (Angioneura) abdominalis

72 – Cerci and surstyli, posterior view.

73 – Hypandrium, gonopod, paramere and basal apodeme, lateral view.

74 – Cerci and syrstylus with epandrium at left, lateral view.

75 – Pump sclerite.

76 – Tenth sternum, ventral view.

77 – Aedeagus, lateral view.

Melanomya (Angioneura) flavescens

78 – Cerci and surstyli, posterior view.

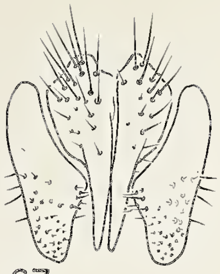
79 – Cercus and surstylus, lateral view.

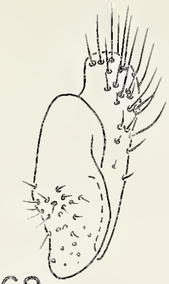
80 – Aedeagus, lateral view.

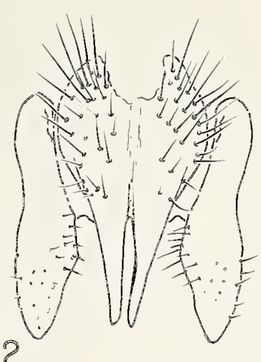
81 – Gonopod and paramere with part of hypandrium shown at top of figure, lateral view.

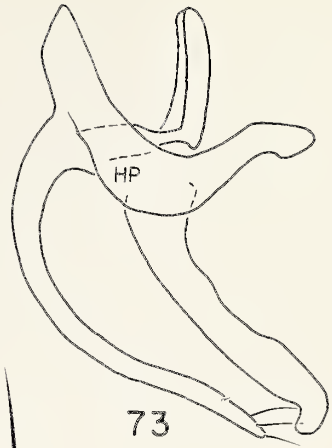
82 – Pump sclerite.

Abbreviations: EA, epandrium ("second genital tergum"); HP, hypandrium ("ninth sternum").

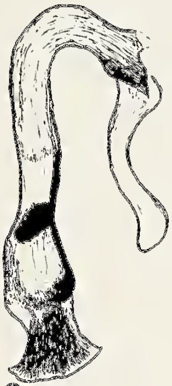

67

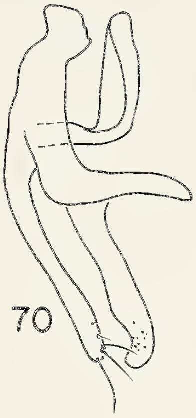

68

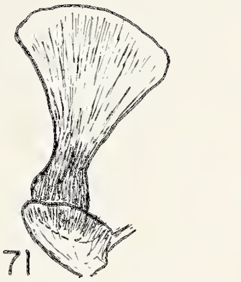

72

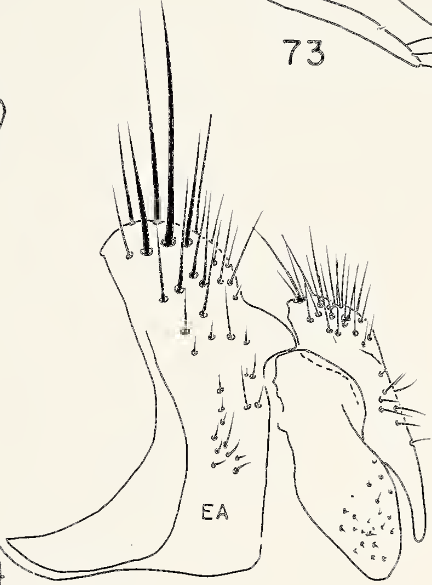


73

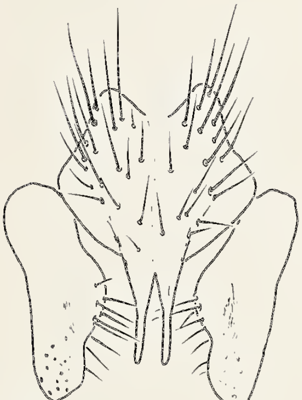

69

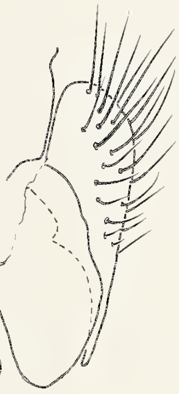

70

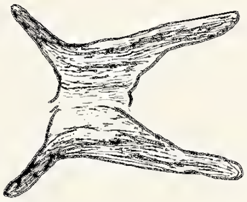

71

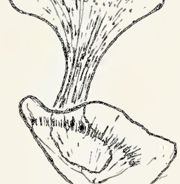


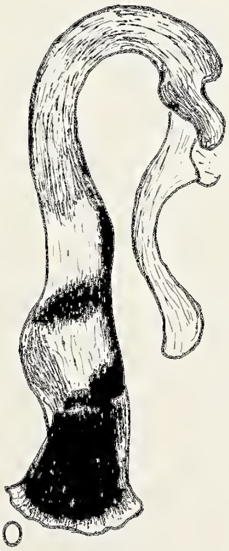
74

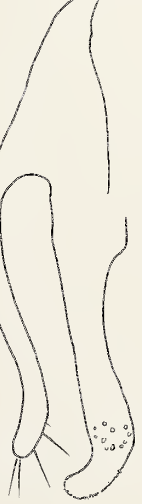

78

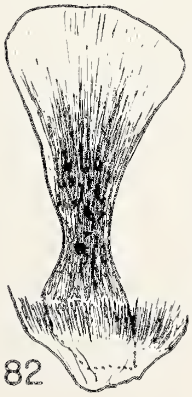

79

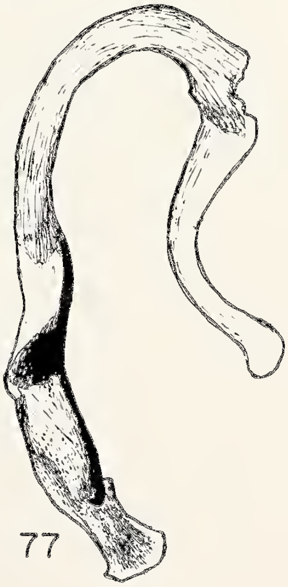

76


75


80


81


82


77

NEW YORK STATE EDUCATION DEPARTMENT
ALBANY, NEW YORK 12234

NON-PROFIT ORG.
U. S. POSTAGE
PAID
Albany, N.Y.
Permit No. 293

1986

Bulletin No. 460
New York State Museum

ISSN 0278-3355
ISBN 1-55557-000-3

ex

Asa Fitch and the Emergence of American Entomology

With an Entomological Bibliography and a Catalog of Taxonomic Names and Type Specimens

by Jeffrey K. Barnes

The University of the State of New York
The State Education Department
Albany, New York 12230

Very Truly Yours,

Asa Fitch.

Dr. Asa Fitch, April 1, 1869 (Courtesy Yale University Library [Asa Fitch Papers]).

ASA FITCH AND THE EMERGENCE OF AMERICAN ENTOMOLOGY

With an Entomological Bibliography and a Catalog of Taxonomic Names and Type Specimens

Jeffrey K. Barnes
New York State Museum
Albany, New York 12230

1988

SMITHSONIAN
MAY 6 1988
LIBRARIES

New York State Museum
Bulletin No. 461

ISSN:0278-3355
ISBN:1-55557-006-2

The University of the State of New York
THE STATE EDUCATION DEPARTMENT
Biological Survey
Albany, New York 12230

The State Education Department does not discriminate on the basis of age, color, religion, creed, disability, marital status, veteran status, national origin, race, or sex in the educational programs and activities which it operates. Inquiries concerning this policy of equal opportunity and affirmative action should be referred to the Department's Affirmative Action Officer, Education Building, Albany, NY 12234. Phone (518) 474-1265.

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of The University *(with years when terms expire)*

1994	Martin C. Barell, *Chancellor,* B.A., I.A., LL.B., LL.D.	Muttontown
1994	R. Carlos Carballada, *Vice Chancellor,* B.S., L.H.D., D.Sc.	Rochester
1988	Willard A. Genrich, LL.B., L.H.D., LL.D., Litt.D., D.C.S., D.C.L., Sc.D.	Buffalo
1989	Emlyn I. Griffith, A.B., J.D., L.H.D., Sc.D., LL.D.	Rome
1991	Jorge L. Batista, B.A., J.D., LL.D.	Bronx
1993	Laura Bradley Chodos, B.A., M.A.	Vischer Ferry
1991	Louise P. Matteoni, B.A., M.A., Ph.D.	Bayside
1988	J. Edward Meyer, B.A., LL.B., L.H.D.	Chappaqua
1988	Floyd S. Linton, A.B., M.A., M.P.A., D.C.L., LL.D.	Miller Place
1988	Salvatore J. Sclafani, B.S., M.D.	Staten Island
1989	Mimi Levin Lieber, B.A., M.A.	Manhattan
1992	Shirley C. Brown, B.A., M.A., Ph.D.	Albany
1990	Norma Gluck, B.A., M.S.W., LL.D., L.H.D.	Manhattan
1990	Thomas R. Frey, A.B., LL.B.	Rochester
1990	James W. McCabe, Sr., A.B., M.A.	Johnson City
1993	Adelaide L. Sanford, B.A., M.A., P.D.	Hollis

President of The University and Commissioner of Education
Thomas Sobol

Executive Deputy Commissioner of Education
Robert J. Maurer

Deputy Commissioner for Cultural Education
Carole F. Huxley

Assistant Commissioner for the State Museum
Martin E. Sullivan

Director, Research and Collections
Paul J. Scudiere

Chief Scientist, Biological Survey
Norton G. Miller

Preface

On April 15, 1836, the New York State Legislature authorized the governor to employ several scientists to make a complete geological and natural history survey of the State (Laws of New York, Chapter 142, 1836). The plan for the survey, which had been drawn up by Secretary of State John A. Dix, directed attention to the need for knowledge of the habits of injurious insects (New York State Assembly Document 9, 1836). Although the New York project floundered for several years before gaining a firm footing, Dix's plan eventually helped to establish entomology as a profession and as an essential government function. The sesquicentennial of the establishment of the original survey, lineal ancestor of the Science Service of the New York State Museum, provides an excellent opportunity to review this aspect of the history of American entomology.

On May 4, 1854, Dr. Asa Fitch was appointed Entomologist of the New York State Agricultural Society, which had received an appropriation for this purpose from the State Legislature. He thus became the first salaried, professional entomologist in the United States. His celebrated career established the model for professional entomologists in the civil service, and he is remembered as a prime mover in the development of entomology as a profession in America.

Dr. Fitch (1809-1879) lived and worked during an exciting period in American history, one of great human advancement and rapid expansion of the new nation. Agriculture, the cornerstone of the economy, was also expanding and undergoing revolutionary changes. Victorian Americans believed that knowledge is power and that social and material leadership would result from the application of science to the common purposes of life. Influenced by a complex web of moral, political, social, and economic elements, entomology emerged during Dr. Fitch's lifetime as an important, recognized profession. At the beginning of his career, insects were generally regarded as insignificant creatures and only occasionally as serious pests. Shortly after the end of his career, entomology became firmly established in America, largely because the teaching, research, and extension network provided a market for professional entomologists. Dr. Fitch's biography is, in essence, a story of the emergence of American entomology.

In this biography, I have attempted to describe the cultural arena in which Dr. Fitch was stimulated to pursue an essentially unoccupied field of study and to highlight the lasting contributions he made to American entomology. Considerable confusion exists concerning his publications and taxonomic work, apparently because few scientists have had an opportunity to study his manuscript notes. I have therefore appended a bibliography of Dr. Fitch's entomological publications and a catalog of the taxonomic names he proposed, along with a description of his type series.

J. K. Barnes

Albany, New York
May 1985

Acknowledgments

I am grateful to T. L. McCabe for suggesting this project and for bringing to my attention the extensive manuscript notes of Asa Fitch deposited in the New York State Museum. For their assistance in searching for relevant material and for permission to publish archival material I thank the staffs and/or members of the Boston Public Library, Boston; Department of Manuscripts and University Archives, Cornell University Libraries, Ithaca; Dr. Asa Fitch Historical Society, Salem; Museum of Comparative Zoology, Harvard University, Cambridge; Museum of Science, Boston; New York State Archives, Albany; New York State Library, Albany; Academy of Natural Sciences, Philadelphia; Rensselaer Polytechnic Institute Archives, Troy; Smithsonian Institution Archives, Washington, D. C. ; Sterling Memorial Library (Manuscripts and Archives), Yale University, New Haven; and the Systematic Entomology Laboratory, U. S. Department of Agriculture, Washington, D. C. For their interest, assistance, and suggestions, I owe a special debt of gratitude to F. Cadwell, G. P. Colman, A. Cormier, L. L. Deitz, R. J. Gagné, E. Gossen, L. Knutson, T. L. McCabe, N. G. Miller, R. H. Monheimer, J. H. Perkins, P. J. Scudiere and E. H. Smith. New combinations and new senior synonyms were provided by R. J. Gagné (*Cecidomyia grossulariae* and *C. thoracica*), R. D. Gordon (*Valgus serricollis*), J. M. Kingsolver (*Bruchus fabae*), and T. L. McCabe (*Attava aurea* and *Geometra*(?) *siccifolia*). The task of entering the manuscript on word processor diskettes was ably, efficiently, and cheerfully performed by two dedicated secretaries, Cheryl Tribley and Gayle Femminella. Cover photograph courtesy Department of Manuscripts and University Archives, Cornell University Archives.

Contents

Preface iii

Acknowledgments iv

1. Family Background, Childhood, and Early Education 1
2. Some Early Nineteenth Century Scientific and Agricultural Developments in New York State 5
3. On the Erie Canal 10
4. At the Rensselaer School 15
5. Medical Education 18
6. To the Western Frontier 25
7. Back Home 29
8. More Scientific and Agricultural Developments in New York State 37
9. Dr. Fitch's Early Professional Involvements with the Scientific and Agricultural Community 45
10. The State Supports Entomological Research 52
11. Dr. Fitch's Contributions to Economic Entomology 60
12. The Later Years 71

Appendix A. Entomological Publications by Dr. Asa Fitch 76

Appendix B. The Taxonomic Work, Collections, and Types of Dr. Asa Fitch 83

- I. Generic Names Proposed by Dr. Fitch 88
- II. Specific and Subspecific Names Proposed by Dr. Fitch 89
  - CLASS CRUSTACEA 89
    - Order Isopoda 89
      - Family Oniscidae 89
  - CLASS INSECTA 89

Order Collembola 89
  Family Poduridae 89
  Family Sminthuridae 89
Order Plecoptera 90
  Family Taeniopterygidae 90
  Family Capniidae 90
Order Orthoptera 90
  Family Tettigoniidae 90
  Family Oecanthidae 90
Order Psocoptera 90
  Family Psocidae 90
Order Hemiptera 90
  Family Cicadidae 90
  Family Membracidae 90
  Family Cicadellidae 92
  Family Cercopidae 97
  Family Delphacidae 97
  Family Derbidae 97
  Family Cixiidae 98
  Family Achilidae 98
  Family Issidae 98
  Family Psyllidae 99
  Family Aleyrodidae 99
  Family Aphididae 99
  Family Adelgidae 103
  Family Phylloxeridae 103
  Family Diaspididae 103
  Family Coccidae 103
  Family Anthocoridae 104
  Family Tingidae 104
  Family Lygaeidae 104
  Family Pentatomidae 105
Order Thysanoptera 105
  Family Aeolothripidae 105
  Family Thripidae 105
  Family Phlaeothripidae 105
Order Neuroptera 105
  Family Coniopterygidae 105
  Family Hemerobiidae 105
  Family Chrysopidae 106
Order Coleoptera 107
  Family Cicindelidae 107
  Family Buprestidae 107
  Family Coccinellidae 107
  Family Meloidae 108
  Family Scarabaeidae 108
  Family Cerambycidae 108

Family Chrysomelidae 108
Family Bruchidae 109
Family Scolytidae 109

Order Mecoptera 109
Family Boreidae 109

Order Diptera 109
Family Trichoceridae 109
Family Culicidae 109
Family Chironomidae 109
Family Sciaridae 109
Family Cedidomyiidae 110
Family Asilidae 110
Family Empididae 110
Family Diopsidae 110
Family Platystomatidae 111
Family Tephritidae 111
Family Sciomyzidae 111
Family Lauxaniidae 111
Family Milichiidae 111
Family Chloropidae 111
Family Anthomyiidae 111
Family Cuterebridae 111

Order Lepidoptera 112
Family Pieridae 112
Family Nymphalidae 112
Family Nolidae 112
Family Arctiidae 112
Family Noctuidae 112
Family Notodontidae 112
Family Lymantriidae 112
Family Lasiocampidae 113
Family Geometridae 113
Family Pyralidae 113
Family Pterophoridae 113
Family Olethreutidae 113
Family Tortricidae 114
Family Cochylidae 114
Family Cossidae 114
Family Gelechiidae 114
Family Oecophoridae 114
Family Plutellidae 114
Family Yponomeutidae 114
Family Gracilariidae 114
Family Incurvariidae 115

Order Hymenoptera 115
Family Cimbicidae 115
Family Diprionidae 115

Family Tenthredinidae 115
Family Cephidae 115
Family Braconidae 115
Family Aphidiidae 115
Family Ichneumonidae 116
Family Eulophidae 116
Family Encyrtidae 116
Family Torymidae 116
Family Pteromalidae 116
Family Eurytomidae 117
Family Eucoilidae 117
Family Charipidae 117
Family Cynipidae 117
Family Diapriidae 118
Family Scelionidae 118
Family Platygasteridae 118
Family Formicidae 118

CLASS ARACHNIDA 119
Order Araneida 119
Family Theridiidae 119
Family Epeiridae 119
Family Dictynidae 119
Unplaced Araneida 119
Order Acarina 119
Family Ixodidae 119
Family Uropodidae 119
Family Acaridae 119
Family Oribatulidae 119

CHAPTER ONE

Family Background, Childhood, and Early Education

In 1638, the Reverend James Fitch, with his widowed mother and four brothers, emigrated from Bocking, Essex County, England, and settled in Connecticut. Among the many sons in the early generations of his family in America were statesmen, soldiers, preachers, judges, doctors, lawyers, and educators. The precedent of leadership set by the Puritan Fitches was followed for generations by their descendants. It has been said that they persistently adhered to a family code of pedigree, prudence, pride, and purse. They always went forth with the Bible in the left hand and the purse in the right.[1] They helped push back the wilderness and found new settlements, even in the second and third American generations. After the Revolutionary War, many of the Fitches joined in the exodus from Connecticut. Some Americans went for adventure, whereas others wanted to occupy lands that had been granted as compensation for destruction of their homes during the Revolution; still others fled from burdensome taxes, bleak winters, and infertile New England soils.[2]

Dr. Pelatiah Fitch, a great grandson of the Reverend James Fitch and grandfather of Professor Asa Fitch, was a physician, justice of the peace, surveyor, innkeeper, and merchant in Connecticut. In 1774 he moved to Halifax, where Governor George Clinton appointed him first judge of Cumberland County, New York (now Windham and Windsor Counties, Vermont). He found the lands in the flourishing town of New Perth, New York (now Salem, Washington County, New York) far superior to those of the rough, sterile, mountainous region of Vermont where he lived. About 1780 he moved to New Perth and practiced medicine, farming, and innkeeping. During the latter part of the Revolutionary War he aided the patriotic cause by serving in the New York Militia, equipping several sons for service in the war, and serving as "Commissioner for Detecting Conspiracies Against the Liberties of America."[3]

Asa Fitch, youngest son of Pelatiah, moved to Salem with his parents. He served during the Revolution and later practiced medicine in Duanesburgh, New York. In 1795, he returned to Salem and purchased a mill property and farm from his wife's father and brother, since known as Fitch's Point. Dr. Fitch became renowned for his large medical practice, and his extensive library and anatomical museum attracted many students seeking instruction. He was instrumental in obtaining passage of a law for the incorporation of the state and county medical societies and served for many years as President of the Washington County Medical Society. He also served as justice of the peace, county judge, and member of Congress, and was active and prominent in the Presbyterian Church, County Bible Society, State Temperance Society, and the Washington County Agricultural Society.[4] In 1791, Dr. Fitch married Abigail Martin. A stout, robust, strong-constitutioned, and industrious woman of large stature, Abigail was fond of reading and apparently made a good wife and mother.[5]

Dr. Fitch and his wife had eight children. Their sixth

Salem, New York, circa 1841 (From J.W. Barber & H. Howe, Historical Collections of the State of New York *[1841]).*

child, also named Asa, was born on February 24, 1809, at Fitch's Point. Shortly after his birth, Salem was described in Spafford's *Gazetteer of the State of New York* as a "post-township," 46 miles northeast of Albany. The Great Northern Turnpike, from Lansingburgh, New York, to Wells, Vermont, led through the township and was one of the best roads in the State. Several small streams allowed for an abundance of mill seats, and the area's agriculture was respectable and rapidly improving. In 1810, Salem's population was 2833.[6]

Asa spent his childhood on the family farm, passing many days with his cousin Josephus Fitch, building waterwheels, dams, bridges, forts, boats, and other imitations of what they saw adults do.[7] He also enjoyed skating, sleighing, hunting, fishing, and the attendant excursions "around, over, through, across, into, upon, down to, the fields, the meadows, the creeks, the roads, the orchards, the hills, the woods. . . ."[8] A shy child, Asa was conscious of an inability to speak in public, or even in private, about almost any subject, and considered himself as possessing only a small amount of general knowledge.[9] It appears that he had little reason to lack self-confidence. Early entries in his diaries betray keen powers of observation and a rare ability to express himself accurately and clearly.

When Asa was about 12 years old, he and Josephus became ill with the measles. That he was not expected to live was obvious to him from the appearance of relatives who were constantly weeping.[10] Although the disease abated, it left him feeble and emaciated.

Asa received his early education in a local school taught on Fitch's Point by a Mr. Harry Brown, but his father, unwilling to spend a large sum for the formal education of another son, hoped he would become a farmer.[11] His eldest brother, Martin, had been provided with a literary and medical education, but when nearly ready to begin practice, he died from consumption.[12] Asa's physical weakness, however, induced his father to send him to the Washington Academy in Salem Village.

Asa attended the Academy from 1822 to 1824, but quickly lost interest due, in part, to a mind that wandered easily.[13] He felt that personal laziness held his progress to less than half what it should have been.[14] He declared that his mind was far from being as it should be, and the Washington Academy "is not a fit place for a convicted sinner."[15] However, Asa persisted with his studies, pursuing French, Latin, history, arithmetic, English grammar, composition, declamation, geography, penmanship, and other subjects. Leading roles in literary clubs and an early fascination with botany provided constructive diversions.[16] He even systematically arranged the plants that his beloved teacher, Mr. Weller, had collected.[17]

In October, 1824, Asa moved to Bennington to attend school. Homesickness soon overtook his initial eagerness.[18] While home for Christmas he apparently felt overjoyed to declare, "Oh there's no place like home — sweet home."[19] The following February he left Bennington for good.

Washington Academy, Salem, New York, in 1985.

Religion became a subject of deep speculation and meditation. A year after recovering from the measles he remembered having felt confident earlier that his sins had been pardoned — that happiness should reign through eternity, but he wondered why such confidence had prevailed. He now admitted to sinning throughout life and seldom thinking of religion.[20] In 1824, when Salem was overwhelmed by a religious revival, Asa reported that the town had never seen such days as these; the revival was progressing in all directions. "Most of the population of the town is gathered from time to time together, to conferences, & other religious meetings. Convictions & conversions are experienced by those who have lived in the most proflegate [*sic*] manner. It seems one continued Sabbath."[21]

Asa became involved in the revival and attended a conference at which his father's exhortations stirred the youth's religious fervor. "Oh! whilst the Holy Spirit is visiting many, would that he might not pass by me! Oh, that I could but obtain a hope that I was born again — that I might not despise things that pertain to my everlasting peace & happiness. . . ."[22] Asa was deeply impressed by the revival. "Oh that I might meditate more frequently on death & its awful consequences, if I live a sinful life in this world. That I might strive to have a place appointed for me in the new Jerusalem."[23] On May 7, 1824, he was examined for membership in Reverend Tomb's Presbyterian Church. "How great a privilege to belong to a Christian church. My most ardent hope is, that I am not unworthy of such distinction."[24] On June 6, Asa was admitted to take communion.

The following year, Asa worked for a brief period in a Salem general store that carried sugar, tobacco, tea, allspice, raisins, blankets, Jamaican rum, and other goods.

He was employed to mark and store away goods, clean, post accounts, and make deliveries. This mercantile experience taught him much about the value of property, the necessities of life, what money was, and, partly, what man was. However, much time at the store was passed in idleness. For some reason he did not enjoy reading as much as he used to, and he regretted making so little progress in literature. He began to experiment with alcohol and even dared a man to drink one-and-a-half pints of rum in 15 minutes. "He said it was fine times when liquor could be got without any pay, & gulped it down — then climbed down into a half dug well, & laid there so dead drunk, I was frightened with fears that I had killed him." The man slept and recovered.[25]

Because Asa saw people of all ages and conditions drinking liquor at the store, he felt there was no harm in doing the same. At first he did it occasionally, but he soon drank daily. Expecting to be a merchant the rest of his life, he felt it was important to be a judge of liquors. He rationed himself to half a glass a day, but, being his own measurer, the ration began to increase. "Should I ever be a *drunkard*? The thought scared me. I thank God for bringing me to reflect upon my danger." Resisting the gratification of his appetite, he lost all inclination to imbibe.[26] In 1829 he joined the Temperance Society in Salem and swore total abstinence from spirits, except as a medicine.[27] Asa later became involved with the Stillwater Temperance Society and the Sons of Temperance, and in 1847 he went to New York City to join the Grand Division. On the day of his initiation he noted, "In the lower story of the same building is a nine-pin alley, *and a bar*."[28]

REFERENCE NOTES

[1] R. C. Fitch, *History of the Fitch Family, A. D. 1400-1930* (published privately by the Fitch family, 1930), Vol. 1, pp. 96-97 (hereafter cited as Fitch, *History*); K. Loughlin, *Miss Abby Fitch-Martin* (New York: Coward-McCann, Inc., 1952), pp. 3-4.

[2] Fitch, *History*, pp. 96-104.

[3] C. Johnson, *History of Washington Co., New York* (Philadelphia: Everts & Ensign, 1878), p. 184 (hereafter cited as Johnson, *History*); A. M. Fitch-Andrews, Asa Fitch and his ancestry, *N. Y. Geneal. & Biogr. Rec.* 34 (1903): 155-158 (hereafter cited as Fitch-Andrews, Asa Fitch).

[4] Johnson, *History*, pp. 184-185; Fitch-Andrews, Asa Fitch.

[5] A. M. Fitch-Andrews, undated manuscript copied from her father's (Asa Fitch's) genealogy notes, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University.

[6] H. G. Spafford, *A Gazetteer of the State of New York* (Albany: H. C. Southwick, 1813), p. 291.

[7] Asa Fitch Diary, 17 Aug. 1865 and 17 Mar. 1868, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University (hereafter records from the Fitch Diary are cited as Diary, followed by the date of the record). Fitch's diary, in 22 volumes designated A, C-G, 1-15, and *Memorandum Book of Farm*, covers much of his life from 1821, when he was a schoolboy of twelve, to 1879, the year he died.

[8] Diary, 16 Sept. 1825.

[9] *Ibid.*, 23 Feb. 1827.

[10] *Ibid.*, 24 Feb. 1822.

[11] *Ibid.*, 31 Dec. 1829.

[12] Johnson, *History*, p. 186.

[13] Diary, 24 Feb. 1822.

[14] *Ibid.*, 31 Dec. 1829.

[15] *Ibid.*, 6 Apr. 1824.

[16] *Ibid.*, 4 Jun. 1824.

[17] *Ibid.*, 2 July 1824, 31 Dec. 1829.

[18] *Ibid.*, 13 Oct. 1824.

[19] *Ibid.*, 25 Dec. 1824.

[20] *Ibid.*, 24 Feb. 1822.

[21] *Ibid.*, 28 Mar. 1824.

[22] *Ibid.*

[23] *Ibid.*, 4 Apr. 1824.

[24] *Ibid.*, 7 May 1824.

[25] *Ibid.*, 21 Dec. 1825.

[26] *Ibid.*, 23 Feb. 1827.

[27] *Ibid.*, 26 Feb. 1829.

[28] *Ibid.*, 5 May 1847.

CHAPTER TWO

Some Early Nineteenth Century Scientific and Agricultural Developments in New York State

After the Revolutionary War most Americans, concerned with the problems of day to day life, were unwilling to cultivate science. Those who did were mainly young amateurs with broad interests. The academies and colleges specialized in classical education; professional instruction in the sciences was almost nonexistent. Nevertheless, American political philosophers saw a close connection between science and political thought. Government was seen as the science of society, and a great interest in obtaining practical results from the sciences developed. Science eventually flourished in America as a panacea for social, political, and economic ills.

Albany, New York, chosen as the State's capital in 1797, became a hub of scientific activity early in the nineteenth century. Intellectual societies interested in the promotion of useful knowledge were soon knocking at the doors of legislators, asking for governmental support for a variety of social, political, and economic causes. The ranks of the societies were filled with men whose tastes and talents ran the gamut from politics to science to agriculture. They pointed out that legislative aid could encourage the discovery of natural resources and assist in making decisions about the advisability of various public improvements. A wave of scientific and political activity passed over the Upper Hudson Valley, and an urgent desire for internal improvements developed.[1]

This activity had many fortunate consequences for New York State and the nation. One was the arrival of Amos Eaton in the Albany area. Eaton had had an interest in natural history since his childhood in Chatham, in the Hudson Valley south of Albany. Although natural history was then a popular pastime, it provided few means for making a living. Soon after graduating from Williams College in 1799, Eaton went to New York City to study law in the office of Judge Josiah O. Hoffman. There he made persistent efforts to simplify legal and scientific jargon so it could be understood by the common man. This fascinated another student in Hoffman's office, Washington Irving, who was then nurturing an ambition to write.

Amos Eaton (Engraved by Alexander H. Ritchie, from Dictionary of American Portraits *[1967]).*

Eaton and Irving became friends of William Van Ness, legal advisor to the Livingstons, Van Rensselaers, and other influential families from the Hudson Valley. Van Ness persuaded William Livingston to hire Eaton as agent for his vast land holdings in the Catskill Mountains, and in 1803 Eaton moved to the village of Catskill, where he collected rents for Livingston. Disliking this employment, in 1806 he began payments on a large tract of land in the Catskills and opened an office as an independent realty attorney. He also dreamed of founding a botanical institution in Catskill, which he did in 1810.

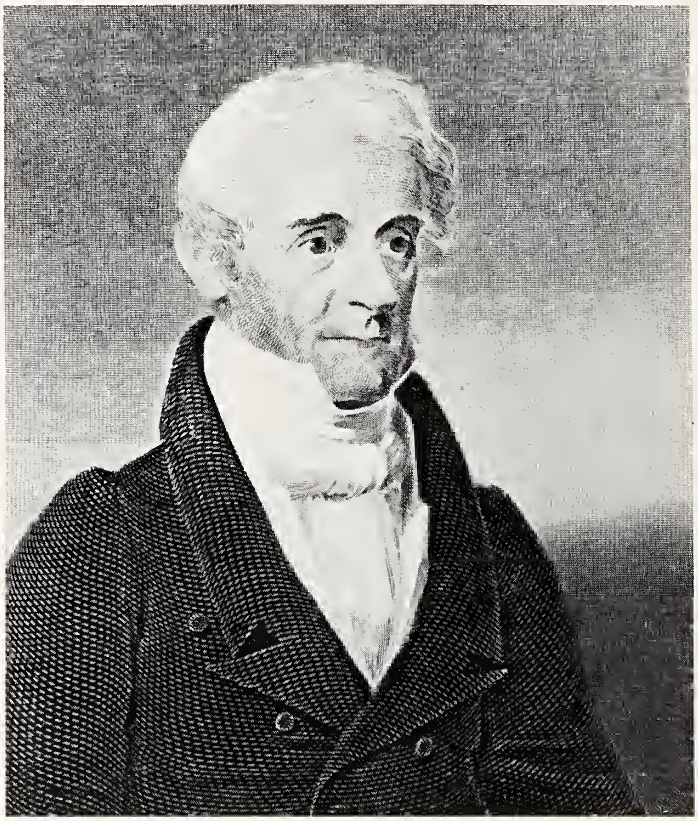
The institution was successful, and having been assured in 1806 that he could use the land he was buying as negotiable security, Eaton decided to sell a few acres and use the profits to purchase equipment for the institution. The owner of the land refused to cooperate and filed charges that Eaton had forged a document relating to their 1806 agreement. Eaton was found guilty in 1811 and sentenced to life imprisonment.

While imprisoned in New York City, Eaton was introduced to the warden's son, John Torrey, who later became a renowned botanist. Inside the prison walls, Eaton taught botany to Torrey. Professor Samuel Mitchell of Columbia College also started visiting Eaton, and Torrey's father began bragging about his prize prisoner. When Mayor DeWitt Clinton became aware of Eaton's clearness of expression, ability and willingness to teach the common man, and knowledge of natural history, he saw the value of these attributes to his gubernatorial campaign, which he planned to build around the Erie Canal issue. Clinton knew that, in order to win legislative approval for the construction of the Erie Canal, he would need to marshal persuasive information about the natural resources and economic potential of the canal route. Governor Tompkins ordered the release of Eaton in 1815, perhaps to avoid political embarrassments in the 1816 campaign and to placate Clinton, Torrey, Van Ness, and Hoffman, who were asking for Eaton's pardon.

Following Clinton's successful campaign, Eaton went to Yale to study natural history with Benjamin Silliman and then returned to Williams College to lecture on natural history. His "common talk" lectures were so lucid and innovative that he won high praises and was awarded an honorary master of arts degree and a permanent faculty appointment. In September, 1817, he was pardoned unconditionally by Governor Clinton, who invited him to Albany to lecture on the natural history and economic potential of western New York.

By 1817 Clinton had persuaded the state legislature to approve initial funding for construction of the "grand canal," but the appropriation provided only enough for a shallow channel between the Hudson River and Lake Ontario. Approval would be needed to extend the canal from Lake Ontario to Lake Erie, thus passing by Niagara Falls and admitting boat traffic to the four upper Great Lakes. During the spring, 1818, legislative session, Eaton delivered his initial lectures before Albany's Society for the Promotion of Useful Arts. His common talk approach was persuasive, and funds were appropriated to extend the canal to Lake Erie.[2]

After one of his lectures, several men from Troy introduced themselves to Eaton, hoping to obtain his services as a lecturer for their fledgling Lyceum of Natural History. One of the sponsors of the Lyceum, Stephen Van Rensselaer, was especially impressed with Eaton's style and scholarship. It was an auspicious moment for the advancement of American science. The influential Van Rensselaer was the eighth patroon of Rensselaerwyck, a Dutch manorial estate that enveloped the whole mid-Hudson region. It had been granted to one of his ancestors by the Dutch West Indies Company early in the seventeenth century. Leaving the management of his estate to others, the wealthy and well-educated Van Rensselaer was able to perform many public services that he considered his duties. He had a talent for combining these duties with private interests without apparent conflict. Van Rensselaer's special interest was public, internal improvements, especially with regard to agriculture.[3]



Stephen Van Rensselaer (Courtesy New York State Library).

Before Eaton's Troy lecture series ended, Clinton and Van Rensselaer were pledging funds for a second series in Albany, exclusively for legislators. This time Eaton was to speak on applications of geology and chemistry to agricultural improvements. The series was well attended, and a certificate of honor was presented to the "master teacher." A week later, on April 9, 1819, the legislature passed New

York's first act appropriating funds for the promotion of agriculture. New York thus became one of the first states, along with Massachusetts, to embark upon a liberal program of state aid to agriculture. The act appropriated $10,000 annually for six years, authorized the formation of county agricultural societies, and established a State Board of Agriculture. Stephen Van Rensselaer became the Board's first president.[4]

In 1820, Eaton and Theodoric Romeyn Beck, principal of Albany Academy and a renowned physician and naturalist, conducted a geological and agricultural survey of Albany County under the direction of the county agricultural society. This was the first attempt in this country to collect and arrange geological facts for the improvement of agriculture. Because it proved useful, Van Rensselaer directed Eaton to conduct a similar survey of Rensselaer County. Eaton was assisted by T. R. Beck's brother, Lewis Caleb Beck, also an eminent physician. The surveyors used a system of neighborhood interviews to collect information for an agricultural calendar based on the experience of working farmers. Their report was so successful that Van Rensselaer was persuaded to support a survey of the entire area adjoining the Erie Canal. Eaton's 1824 report on this survey had a revolutionary impact on geology, primarily because of his new nomenclature.[5]

Bedridden with illness during the summer of 1824, Eaton focused his attention on education. He was convinced that science should be simplified and taught to excite the mind. Like many other philosophers of the era, Eaton also believed that economic and social enrichment could result from the application of science to the common purposes of life. Stephen Van Rensselaer shared Eaton's views and in 1824 created the Rensselaer School, to be conducted in Old Bank Place at the north end of Troy. His object was ". . . to qualify teachers for instructing the sons and daughters of farmers and mechanics, by lectures and otherwise, in the application of experimental chemistry, philosophy, and natural history, to agriculture, domestic economy, the arts, and manufactures."[6]

Rensselaer Polytechnic Institute
Original Building, 1824,
On River Street by Orr's paper mill
near the State dam.

Old Bank Place, Troy, New York, original home of the Rensselaer School (Courtesy Rensselaer Polytechnic Institute Archives).

The new school was envisioned as a radical departure from classical education. Van Rensselaer ordered that the students learn by taking turns lecturing and experimenting, and that they be examined by presenting demonstrations. He appointed Amos Eaton to the senior professorship and Lewis C. Beck to the junior professorship. The Rensselaer School became the first institution in the United States for scientific and technical training. Today, as Rensselaer Polytechnic Institute, it is the most enduring monument to the memory of the benevolent patroon.[7]

The Fitch family became deeply involved in the new spirit of improvement that pervaded New York State. Back in Washington County, Asa Fitch's father sold his medical practice in 1820 to Dr. Alfred Freeman. Dr. Freeman had been a medical student of the senior Asa, and was married to one of the Doctor's nieces.[8] With more leisure time, Dr. Fitch became involved in other pursuits. A few months before the State Legislature passed the 1819 law for the promotion of agriculture, several prominent and enterprising citizens of Washington County met, with Dr. Fitch presiding, to consider how the agricultural interests of the county could best be promoted. They decided to organize an agricultural society, and Fitch was elected the first president. The society attempted to make farmers aware of agricultural improvements by holding annual "farmers' holidays" at which there were competitions and interchanges of ideas. It ceased to exist in 1826, due to the limitations of the 1819 State law that initially encouraged it. Washington County would not have another agricultural society until 1841, when the policy of State aid would be revived, and Fitch's son, Asa Jr., would play an active role in the new organization.[9]

Early in 1826, young Asa's only career thoughts were of a life as a merchant. For several years he had enjoyed botany as a pastime, but never thought of natural history as being more than amusement. On March 11, upon returning home from working at the store in Salem, his sister Barbara told Asa that their father and Dr. Freeman felt it would be more beneficial for him to attend the Rensselaer School than remain at the store. They had come to this conclusion by a perusal of the School's constitution, a copy of which had been sent to Dr. Freeman. At first, Asa scoffed at the idea, but on reflecting decided, ". . . tis a surer way to fame than the one I am now pursuing; I shall acquire much useful knowledge by attending there . . . ." The thought of learning more about botany excited him. "Even this, with nothing else I thought would sufficiently reward me for my time etc. & would be a chief amusement during the remainder of my life."

Asa was apprehensive about entering the Rensselaer School. Low self-esteem and shyness stood in his way, but he proceeded with the plan. Late in March he started going to the Washington Academy to brush up on English grammar and arithmetic. On April 5, he went to Troy and the next day visited the school "to see how it looked & what sort of folks were there." Having heard of Professor Eaton, he imagined this man of science to be "one who knew everything, very stylish, & neat – perhaps foppish." Asa trembled every step of the way, fearing his performance might expose him to "the sarcastic, or more likely the contemptuous thoughts of those whom I saw." Finding no door at first, he went down to view a sloop-lock on the canal. "Should I ever reside in them [*sic*] brick walls? Become acquainted with its inmates? It seemed impossible."

Asa finally found an entrance to the school and trembled all the way as he was led to Professor Eaton. He was surprised to see immediately that Eaton was an ordinary man, and apparently far inferior to many past acquaintances. The professor's dress shocked him:

> There he sat, drawing on a pair of boots that did not look as though they had ever seen either grease or blacking – boots that appeared to be made in the fashion of a former age. His remaining dress, was full as much out of fashion. He had on a cap, made I should judge of squirrel skin, by a hand that had never been engaged in such business before. In short a person of his appearance, is precisely such a one as I should have thought would be hooted out of town.

Nearly all of Asa's timidity vanished upon seeing Professor Eaton. He conversed freely and found that the Professor's language was nearly the same as his own. "I received such attention as I did not presume to expect – was conducted through the different rooms, had the whole course explained to me etc. etc. & to conclude was invited to attend the students on a scientific expedition to L. Erie in a few weeks." Asa quickly became enraptured with the idea of attending the Rensselaer School. From perusing the reading room he found that natural history was a truly interesting branch of learning and one that he could pursue with pleasure. Newly discovered confidence, and even vanity, whispered to Asa that he was somebody.[10]

REFERENCE NOTES

[1] J. K. Barnes, Insects in the new nation: A cultural context for the emergence of American entomology, *Bull. Entomol. Soc. Am.* 31 (1985): 21-30.

[2] An excellent summary of the life and accomplishments of Amos Eaton, from which this account is adapted, appears in R. W. Howard, *Dawnseekers, The First History of American Paleontology* (New York: Harcourt Brace Jovanovich, 1975), pp. 79-107 (hereafter cited as Howard, *Dawnseekers*).

[3] S. Rezneck, *Profiles Out of the Past of Troy, New York, Since 1789* (Troy: Greater Troy Chamber of Commerce, 1970), pp. 13-17.

[4] W. Bacon, History of the agricultural associations of New York from 1791 to 1862, *Trans. N. Y. State Agric. Soc.* 23 (1864): 143-168; P. W. Bidwell and J. I. Falconer, *History of Agriculture in the Northern United States, 1620-1860* (Washington: Carnegie Institution, 1925), p. 189; Howard, *Dawnseekers*, pp. 97-98.

[5] Howard, *Dawnseekers*, pp. 97-98.

[6] P. C. Ricketts, *History of Rensselaer Polytechnic Institute, 1824-1934* (New York: John Wiley & Sons, Inc., 1934), p. 9 (hereafter cited as Ricketts, *History*).

[7] Howard, *Dawnseekers*, pp. 106-107; Ricketts, *History*, pp. 9-13.

[8] A. Fitch, undated photostat copy of some Fitch manuscript genealogy notes, New York State Library.

[9] C. Johnson, *History of Washington Co. New York* (Philadelphia: Everts & Ensign, 1878), pp. 103-106.

[10] Asa Fitch Diary, 23 Feb. 1827, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University.

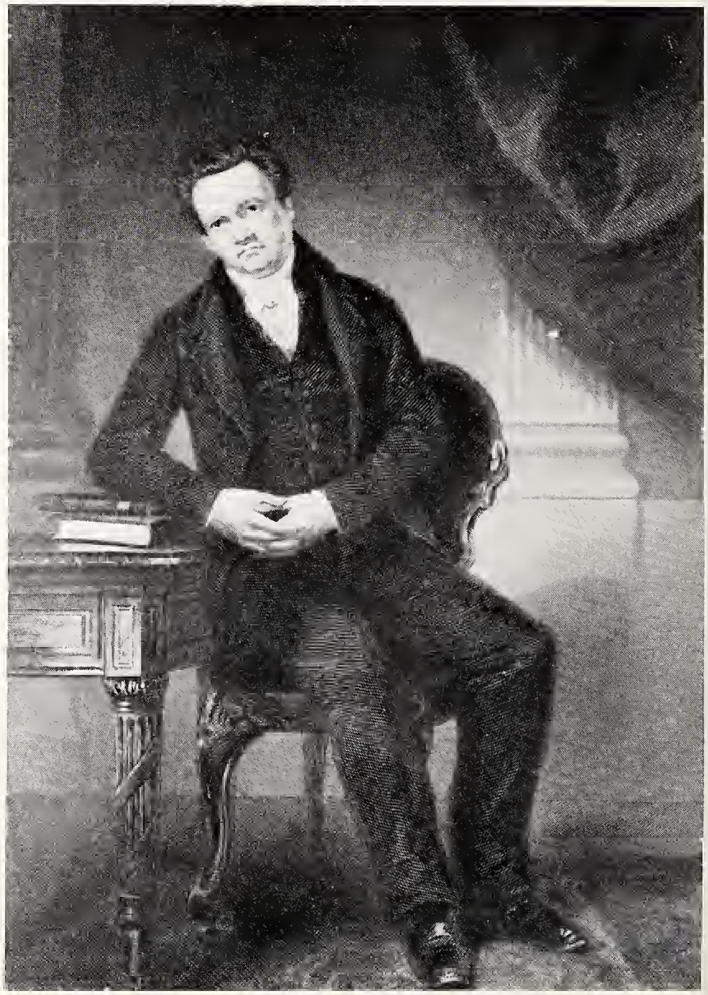
CHAPTER THREE

On The Erie Canal

The idea of building a grand canal across New York State to connect Lake Erie with the Hudson River had been bandied about for many years before DeWitt Clinton was elected governor in 1817. A channel wedding the waters of the Great Lakes with those of the Atlantic Ocean at New York City would provide the Northeast with a quick and easy route to the fertile Midwest and Michigan's mineral lodes. However, savage conditions and political feuds with our neighbors to the north held settlement of western New York to a minimum until American victories in the War of 1812 ensured free access to the Great Lakes.

At first, the proposal to build the canal was fiercely ridiculed, but eventually it gained steam. People who lived along the proposed route, of course, supported the proposal. The eventual passage of the law authorizing construction of the canal changed American history. The Erie Canal and the railroad that came to parallel it strongly influenced the nation's economic and social life. The cost of transportation dropped dramatically. New York City became the nation's largest seaport and New York State became the Empire State. New England developed into a prime commercial trader with the West, partly because of the canal. Americans and immigrants moved west in droves via the canal. In the decades following the Revolutionary War, agriculture was the cornerstone of the American economy, but it was unprogressive and exploitive. Because land was abundant and cheap, farmers found it advantageous to exploit the land for quick profits and then move elsewhere. Soil exhaustion was a serious problem before 1840 in the East and South, and insect pests and diseases further reduced yields. New Englanders were already moving westward in search of richer soils before the Erie Canal was opened, but after 1825 the wave of migration accelerated. By the 1840's, western farmers were successfully competing with their counterparts in New York and New England for the urban markets created by the Industrial Revolution and the expansion of specialized agriculture in the South.[1]

Building the canal was a Herculean task, and the celebration that wedded New York's waters was one befitting an

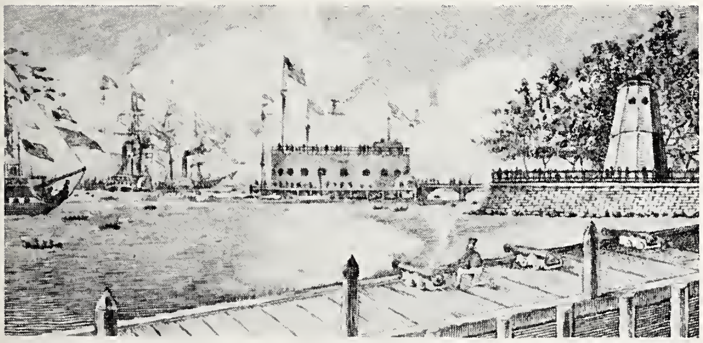


DeWitt Clinton (Courtesy New York State Library).

auspicious and consequential occasion. In Buffalo on October 26, 1825, Governor Clinton boarded the *Seneca Chief*, which was decorated with a huge painting of him depicted as Hercules resting from his labors. On board were two kegs of water from Lake Erie, destined for the ocean at New York City, along with waters from the Mississippi, Rhine, Orinoco, Amazon, Nile, Gambia, Indus, and Ganges Rivers. A flotilla of five boats left Buffalo at 10 A. M. as a cannon fired. Cannon fire was relayed all the way to New York; the last signal, fired at 11: 20 A. M. in New York, triggered a brisk artillery salute.[2] The flotilla made its way to Albany, stopping at towns and hamlets along the canal, where celebrations were held and speeches were heard. In Albany there was an elaborate celebration that included processions of State officials, military units and societies, a parade, and a dinner for a huge crowd. On November 2, Asa Fitch boarded the steamboat *New London*, and the flotilla headed down the Hudson River to New York City.[3]

On the Hudson, Asa perhaps marvelled at the ingenious design of the steamboat. A distant relative and Revolutionary War officer, Lieutenant John Fitch, has been widely credited with having developed the world's first successful steamboat over 20 years before the maiden voyage of Robert Fulton's *Clermont*.[4] On November 4, the boats arrived in New York City, and Asa witnessed the final benediction of the wedding of the waters:

> Twenty five steam-boats crowded with passengers . . . formed in procession in front of the battery, & proceeded to Sandy Hook where two kegs of the water of Lake Erie were poured into the Atlantic by Gov. Clinton. The steam-boats were all decorated with pennons & colors in the most superb style. The procession of the different societies etc. in the city was also very grand. The Coopers, Hatters, Curriers, Comb-Makers, Shoemakers, Saddlers, Printers etc. had each a large car drawn in the procession by horses, on each of which were several men at work at their respective trades.[5]



The Erie Canal Celebration, New York City, November 4, 1825 (Courtesy New York State Library).

In the evening, Asa was entertained by a grand display of fireworks and rockets at Castle Garden, which were all quite novel to him. After a short visit to New Haven to meet relatives, he returned to New York. On November 10, an auction was held at which the cargoes of the canal boats, including a picture of Governor Clinton uniting the waters of Lake Erie with the Atlantic Ocean, were sold.[6] That evening Asa headed for Albany on the *Chancellor Livingston*, complaining that progress was considerably retarded because the *Seneca Chief* was in tow.[7]

With celebrations over, the grand canal's work got underway. As thousands of people moved west via the canal, and goods were efficiently transported across the State, businesses sprang up along the banks, and many towns seemed to double in population overnight.

It is not surprising that the Erie Canal became an outdoor laboratory for students of natural history. Amos Eaton had already made a detailed geological study of the canal route, recording and systematizing the geological layers along this distinctive cut of more than 350 miles. He had lectured on natural history at villages along the canal while engaged in the survey, and had already successfully experimented with the first American use of field trips for teaching natural history while lecturing at Williams College in 1817.[8] Stephen Van Rensselaer, a canal commissioner, had been his patron in the canal survey and school projects.

Professor Eaton wrote Van Rensselaer in March of 1826, explaining that students of the Rensselaer School had requested a scientific tour of the canal. By using a freight boat outfitted with a portable kitchen, the cost of the 700-mile round trip could be held to $20 per student. Mineral samples and fossils could be collected and sold to defray the expenses of the trip.[9]

Less than three weeks after his initial meeting with Professor Eaton, Asa returned to Troy to join the Rensselaer School expedition to Lake Erie. He arrived on April 25, in time to attend the school's first commencement exercises the following day.[10] He began studying geology after receiving a copy of the canal survey at Van Rensselaer's direction.[11] In the company of men of science, his shyness returned and he scarcely knew how to converse with them.[12] Asa quickly took note of the religious attitudes of the students. Although the majority seemed religious, he was shocked by the excessive use of profanity.[13]

On May 2, the travelling school left Troy with a party 26. In addition to eight recent graduates and several current students, there was Joseph Henry, a recently appointed professor at the Albany Academy. He was beginning a scientific career that would bring him renown for his work with magnetism and electricity, and for his role as first secretary of the Smithsonian Institution. James Eights, a freelance scientific draughtsman who had assisted Eaton on earlier tours, was purveyor for the party. George Washington Clinton, son of DeWitt Clinton and a graduate of Hamilton College, also accompanied the party. Professor Eaton, the commander, appointed an assistant each day to report upon poor conduct, stop the boat at places of interest, oversee bed-making, and perform other tasks.[14]

The party travelled on a packet boat named the *LaFayette,* which was pulled by horses or mules on the towpath paralleling the canal. Asa was reminded of a Venetian gondola described by Byron as being just like a coffin clapped in a canoe. The cabin occupied nearly its entire length, leaving only a small deck at each end.[15]

The stove and other cooking gear were placed on the forward deck, an arrangement that worked out well until a shower made it impossible to kindle a fire one afternoon. That evening the party was obliged to eat only bread and butter accompanied by glasses of water. Living conditions were crowded. For sleeping accommodations, boards were placed across benches in the cabin, and mattresses were spread upon them, occupying all available space. Asa described the arrangements in his diary of the expedition:

> And upon them we arranged ourselves to sleep in two rows, which might remind one of the rows of graves in a burying ground. The first night, when one after another of the sleepers had *fallen into line* and arranged themselves upon the mattresses, the narrow space was so thronged that, looking from the deck down into the cabin, it would bring to one's mind the Black Hole of Calcutta.[16]

When it became evident there was insufficient space to accommodate the whole party, several men decided to stay at public houses on shore. Asa contemplated doing the same, but a piece of awning was found, which he and some others spread over the hind deck. Wrapped in a cloak and using a satchel for a pillow, Asa was able to sleep comfortably. On subsequent nights he sometimes lodged in public houses on shore, but as the expedition proceeded, five men from the party stopped at different villages to conduct itinerant lecturing and spread the new Eatonian gospel of American science. Others left as the *LaFayette* approached their homes en route. The company eventually became so reduced that all were able to lodge in the cabin.

Each day the party arose at sunrise, had breakfast at 8:00, dined at 2:00, and had tea after stopping for the night. The boat stopped at localities of geological interest along the way, where the students examined rocks and collected specimens. Travel was slow and leisurely as the boat advanced about 20 miles each day. When the party was detained at a lock or as other opportunities occurred, several men went ashore and walked along the towpath for a few miles, gathering botanical specimens until overtaken by the boat. The tour took place several years before the advent of the temperance reform movement, and Captain Kane, with other boat hands, insisted that the Officer of the Day, appointed each evening by Professor Eaton, bring in a bottle for their entertainment.

Professor Eaton usually lectured on geology in the morning, and a graduate selected by him lectured on botany in the afternoon. At some of the larger villages en route, Eaton gave a public address on the objects of the Rensselaer School and the importance of chemistry and natural history.[17]

On this tour, Asa first demonstrated his interest in insects. On May 4, after the boat put up for the night at a basin "near Sprakers store, west of Flat creek," he walked on the banks of the river, noticing for the first time the "brilliant lamp of the glow-worm." He thought it was a firefly, but upon taking one of the creeping larvae to the boat was informed of his "mistake."[18]

On May 7, the party was at Whitesborough, near Utica. Asa noticed that the area had recently been visited by a powerful religious revival. In his diary he wrote, "Would that while passing through the country where the Holy Spirit is working in the hearts of many of the inhabitants, some of our party might be seized with the flame . . . The members of our expedition are almost universally addicted to the ungentlemanly habit of using profane language . . . Prof. Eaton I believe, cares but little about Religion, only as a show. He did not attend church today. . . Still he would be glad to discourage the profanity of our company."[19]

On May 19, the expedition reached Niagara Falls. From reading splendid accounts of the Falls, Asa's expectations had been high, and they were met, but not exceeded.[20] At Tonawanda Creek, he found fine fishing in a pristine wilderness area and reported that a person could go out in a boat, splash the water with a paddle, and fish would jump from the creek, some of them falling into the boat. Catching them was so easy that they were sold cheaply; bass weighing two or three pounds could be purchased for half a cent each.[21]

On May 23, upon reaching the western end of the journey at Sturgeon Point, Asa felt a tinge of homesickness:

> After wandering . . . in parts where I was utterly a stranger, it was with feelings of no ordinary nature, that I found myself returning to the scenes of my childhood & youth – to the peaceful abodes of relatives & friends of former days. Shall I find them so on my return? Shall all be peace and happiness? Has the destroying angel of Death made his appearance in that dear little circle? Merciful God. I hope not![22]

On May 28, the party was at Rochester on its return trip to the eastern end of the canal. Just as they started making beds, a man appeared at the door and asked for "thees Professor Eaton." It was Constantine Samuel Rafinesque, the famous professor of botany and natural history from the University of Transylvania in Kentucky. Disagreeing with the University's general disregard for science and President Holley's disdain for the subject, he had left the college "with curses on it and Holley." Holley resigned the next year and soon died at sea from yellow fever, and the main college building burned in 1829.[23] Rafinesque was on his way to Philadelphia when he heard about the Rensselaer School expedition at Niagara Falls. He had pursued the expedition and finally caught up with it. There was so much

Constantine Samuel Rafinesque (From Dictionary of American Portraits, *[1967]).*

confusion in the cabin that Asa, in company with Professor Eaton, Professor Rafinesque, Mr. Clinton, and a couple other members of the expedition retired for about an hour to the Canal Hotel. There, Professor Rafinesque agreed to accompany the expedition on the rest of the journey to Troy.

Professor Rafinesque was a valuable, if somewhat eccentric, companion. Born in Constantinople of French-Italian parentage, he had spent most of his life in America as a moneyless, free-lance naturalist. According to Asa, he was regarded as a "universal genius, ready to investigate whatever subject presented itself to him – a full blooded polytechnic."[24] Professor Eaton was delighted with this addition to the party. Rafinesque's *Ancient History; or Annals of Kentucky* had been published in 1824, and his articles in Silliman's *Journal* had attracted much attention, even though they were written in his typical pompous style. At Transylvania he had reviewed Professor Eaton's *Index to the Geology of the Northern States* for *The American Monthly*. Eaton was flattered by Rafinesque's conclusion that "when [Eaton] attempts to show that the geogony of Moses and his account of The Flood do not in the least contradict the facts which experience has revealed, when he proves that the days-of-Creation have been many periods of time, as so many learned divines have asserted and every geogonist believes, we find him engaged in a desirable act of conciliation between science and religion."[25]

The arguments and lectures that resulted from the discussions between Rafinesque and Eaton provided an exciting conclusion to the expedition. Rafinesque was so well versed in zoology and botany that each day the students went to him with specimens to be labelled. However, his zealousness for naming new species earned him a questionable international reputation as a "species monger." According to Asa, "Ah, that is my new species" became a byword in classes at the Rensselaer School the following term.[26] Asa felt that Rafinesque's greatest failing was his separation of many new genera and species without sufficient justification.[27] Nevertheless, he decided that because such a celebrated and knowledgeable figure was present, he would pay some attention to conchology and have Rafinesque or Dr. Eights label his shells.

Indeed, Rafinesque missed greatness by embracing too many fields of knowledge and by caustically criticizing many of his contemporaries, but he is recognized for describing a large number of species.

On June 3, the party left the *LaFayette* to view Green Lake, near Syracuse. Asa took a highly poetic point of view and declared it a perfect setting for a romance. Professor Eaton had never seen it, and apparently was not much interested because he allowed the party only a hasty view. Had there been a rock, a bleak barren rock, in place of the lake, Asa mused, they would all have looked themselves blind and still have been obliged to stay longer.[28]

Professor Rafinesque reported in his autobiography that he went to Troy for a few days, "where I rested awhile with Prof. Eaton, at his school for teachers, founded by Mr. Van Rensselaer to instruct young men in practical natural Sciences, etc., which they learn by giving themselves lessons to each other, admirable plan not yet sufficiently known and adopted elsewhere."[29]

On June 10, the expedition ended, and three days later Asa returned to Salem. Reflecting upon his experience, he thought, "What new ideas I have received! & how greatly my mind has been improved."[30]

The tour, which deeply influenced the 17-year-old farm boy from Salem, was a remarkable educational experience for the era. Lasting a little over five weeks, it had been replete with new and valuable experiences – social as well as scientific. The expedition visited the new towns along the canal that later became New York's principal cities – Rome, Utica, Syracuse, Rochester, and Buffalo. The students absorbed Professor Eaton's vast and incomparable early knowledge of American geology and natural history.

> . . . I have often thought of it, that in those 5 weeks, I learned more – I acquired more useful, practical, valuable knowledge, than in any other 5 – yes, than in any other 10 weeks of my life.[31]

REFERENCE NOTES

[1] P. W. Bidwell and J. I. Falconer, *History of Agriculture in the Northern United States, 1620-1860* (Washington: Carnegie Institution, 1925), pp. 181-182, 324-334. M. W. Rossiter, *The Emergence of Agricultural Science. Justus Liebig and the Americans, 1840-1880* (New Haven: Yale University Press, 1975), pp. 3-9.

[2] D. Tuttle, The wedding of the waters, *Conservationist* 33 (Nov.-Dec., 1977): 10-15.

[3] Asa Fitch Diary, 2 Nov. 1825, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University (hereafter cited as Diary, followed by the date of the record).

[4] R. C. Fitch, *History of the Fitch Family, A. D. 1400-1930* (published privately by the Fitch family, 1930), Vol. 2, pp. 213-237.

[5] Diary, 4 Nov. 1825.

[6] *Ibid.*, 10 Nov. 1825.

[7] *Ibid.*

[8] R. W. Howard, *The Dawnseekers, The First History of American Paleontology* (New York: Harcourt Brace Jovanovich, 1975), pp. 93-95 (hereafter cited as Howard, *Dawnseekers*).

[9] S. Rezneck, Joseph Henry learns geology on the Erie Canal in 1826, *New York History* 50(1969): 29-42.

[10] Diary, 25 April 1826.

[11] *Ibid.*, 27 April 1826.

[12] *Ibid.*, 23 Feb. 1827.

[13] *Ibid.*, 30 Apr. 1826.

[14] *Ibid.*, 2 May 1826.

[15] A. Fitch, undated, untitled manuscript notes on the early years of the Rensselaer School, p. 3, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University (hereafter cited as Fitch, Rensselaer School).

[16] *Ibid.*, p. 4.

[17] *Ibid.*, p. 5; Diary, 2-4 May 1826.

[18] Diary, 4 May 1826.

[19] *Ibid.*, 7 May 1826.

[20] *Ibid.*, 19 May 1826.

[21] *Ibid.*

[22] *Ibid.*, 23 May 1826.

[23] C. S. Rafinesque, *A Life of Travels and Researches in North America and South Europe, or Outlines of the Life, Travels and Researches of C. S. Rafinesque, A. M. Ph. D.* (Philadelphia: printed for the author, 1836), p. 78 (hereafter cited as Rafinesque, *Life*); *The National Cyclopaedia of American Biography* (New York: James T. White and Company, 1897), Vol. 4, pp. 513-514; J. D. Wright, Jr., William W. Kelly, and William T. Young, Transylvania University, pioneering a third century, *Newcomen Publication* 1140(1981): 1-24.

[24] Fitch, Rensselaer School, p. 8.

[25] Howard, *Dawnseekers*, pp. 115-116.

[26] Fitch, Rensselaer School, p. 8.

[27] Diary, 31 May 1826.

[28] *Ibid.*, 3 Jun. 1826.

[29] Rafinesque, *Life*, pp. 82-83.

[30] Diary, 14 Jun. 1826.

[31] Fitch, Rensselaer School, p. 5.

CHAPTER FOUR

At the Rensselaer School

During his five weeks on Fitch's Point following the canal expedition, Asa occupied himself chiefly in labelling rocks and minerals collected on the trip and in studying botany. He also collected shells, adding 160 species and 360 specimens to his collection of 1700 shells. On July 18, 1826, Asa returned to Troy for a year of formal study at the Rensselaer School.

Both Amos Eaton and Stephen Van Rensselaer, striving to influence the general course of education, regarded their new "Rensselaerian Plan" of education in applied science as having universal value and validity.[1] The plan was immensely successful. From the beginning the students learned by doing, and many of them became America's most respected early scientists.

The daily schedule was long and rigorous, but there was also a certain informality. Much responsibility was given to the students, because there was only one senior professor, aided often by the more advanced students. Also, because Professor Eaton was often ill, the students sometimes engaged in youthful mischief.[2]

Asa, whom Professor Eaton regarded as one who "always understands his subject, but . . . knows nothing of experimenting," found much sameness in the way each day was passed. The morning bell rang at sunrise, signalling the students to arise and prepare for examination at the sound of the second bell, 20 minutes later. The students were divided into sections, each of which was examined in the reading room, with all others present, on subjects from the preceding day's lectures. Examinations usually lasted an hour, until the breakfast bell rang. Until about 9 or 10:00, they studied and prepared apparatus. About 10:00, lectures on natural philosophy and natural history began. The lectures of the sections in the common laboratory and the assay room began earlier. They lasted until about dinner time, which was 1:00. From dinner until supper, each student could do as he wished. Supper was at 6:00, and at 7:30 the bell again rang, signalling the students to assemble in the reading room, where they studied until 9:00 or later. Asa usually spent the rest of the evening, until about 11:00, writing poetry, reading Burns's works, or in other literary pursuits.[3]

According to Asa, the board was poor and overpriced, and nearly all the students hated the steward, a Mr. Lockwood, and his family.[4] Perhaps out of disgust he made a bargain with one Howard Wells allowing him to have as many oysters as he could eat for four shillings. After eating 63, he agreed to stop if Wells would give him two dozen more. Asa sold the two dozen for two shillings and thus obtained all he wanted for two shillings. "I believe I could have eat [*sic*] a hundred if I had *crammed* myself. But I got a cheap supper, at all events."[5] Oysters remained one of his favorite foods throughout the rest of his life.

A few days later a meal at the Rensselaer School triggered some entomological exclamations from the student:

> At dinner, in cutting up some boiled cabbage, I found a spider in it almost equal to any I ever saw in size, & so perfect that I could had I been disposed traced out its specific name. I state this to remind me at some future day of the care with which our victuals are prepaired [*sic*]. Our butter consists of about equal proportions of hair & Tobacco acid, our chees [*sic*] has frequently maggots frisking about upon it, there is a bug or fly in almost every dish of tea & coffee we drink etc. etc. etc. If the present class are not all good naturalists the Stewart [*sic*] will not be to blame.[6]

Apparently this experience impressed Asa. When he went home after the first term, he started to collect, analyze, and describe spiders.[7]

On Saturdays there were extracurricular debates among the students, who were organized as a mock Congress of the United States. On Sunday mornings and afternoons the students attended church, and on Monday mornings Professor Eaton lectured on Biblical history and moral philosophy.[8] Asa, a country boy with basic beliefs, was now confronted with life in a new urban and scientific setting.

Troy, New York, circa 1841 (From J.W. Barber & H. Howe, Historical Collections of the State of New York *[1841]).*

He sampled a variety of religious offerings in and around Troy but was disturbed by the deficiency of religion at the new school of science.

July 30, 1826, was a typical Sunday. It began with a morning examination on sacred history, this time on the authenticity of the Scriptures based on geological facts. Professor Eaton's geology was usually reconciled with the Bible, the different strata being classified as originating before or after The Flood. Later in the morning, Asa attended the Baptist Church, and in the afternoon went to his regular Presbyterian Church, where Reverend Mr. Beman, Troy's leading theologian, preached. In the evening he attended more services and returned to the school at 10:00. He attended the Presbyterian Church on most Sundays, but occasionally sampled the services of the famous Watervliet Shakers or the Troy Quakers. Perhaps because of a rigid puritanical background, Asa was uncomplimentary and intolerant of them.[9]

Asa was especially critical of his fellow students for their profanity and lack of religious zeal. He wished he could flee from the company of the ungodly and reflect upon his love of the Great Redeemer. After the Rensselaer School experience was over, he admitted, "I am conscious that I have done many things which were not right, & which require repentance, & prayers for forgiveness. I hope that removed from the most immoral associates I ever had, a new & brighter unclouded day is now dawning, which is to last for life. Oh that my love, & good works may increase, fast as I am hastening down the course of Time."[10]

Despite his religious zeal, Asa was still only a youth of 17 during his first term at the Rensselaer School and also prone to participate in the frivolity that arose in the reading room during evening study hours. Apparently in an effort to overcome his farm-boy shyness, he liked to attract the attention of the other students by "creating a disturbance by buffoonery etc. I wish I was not so anxious to make others laugh at me . . . I must endeavor to reform."[11]

October 31, 1826, was examination day for Asa's first term. "Morning got up & shaved myself. Muttered 50 *'I don't cares.'* " Full of fears and anxieties, the hours passed slowly and many a sigh was uttered. He could not bear to study. The board of outside examiners, which included Joseph Henry, was addressed by Professor Eaton. "Then at it we went. Faces red, hands trembling, legs almost unable to support the body, ears deaf & mouth – dumb . . ." He completed the examination successfully and with a great sense of relief. ". . . It seemed almost as though I had got into a new world."[12]

Asa went home for the winter and had a chance to reflect upon his education. "During the last year my improvement I think has been almost incredible. The ease with which I understand some subjects which were before unintelligible to me, too abstruse for me to comprehend, surprises me." He was delighted with the growth of his intellect, but saw still plainer "the immense distance that I am from maturity in Judgement etc. I see the lofty mountains & the extended plains that I have yet to climb & traverse. But I trust I do not see them so plainly as I shall continue to in each succeeding year."[13]

On March 6, 1827, Asa returned to Troy for a second term of study at the Rensselaer School, now more interested than ever in the study of insects. On March 15, he made drawings of two insects from Gregory's *Dictionary*, and two days later he initiated his collection of insects, which would eventually grow to enormous proportions, with a specimen identified as *Panorpa hyemalis*.[14] Asa soon found that descriptive entomology was a wide-open field. With the Professor's son, Timothy Dwight Eaton, who was "full as crazy in collecting & analyzing as I am," he collected, analyzed, and labelled insects as fast as he could, but did not believe he found the correct names for all of them. When descriptions in Rees' *Cyclopedia* did not agree perfectly with many of his specimens, Asa concluded that many were representatives of new species.[15] On a visit to the Albany Academy, he examined the two completed volumes of Thomas Say's *American Entomology*. "In these, scarce the hundredth part of our insects are described . . . Mr. Say does not hesitate to bring forward new species." Cautiously, Asa concluded that, to a certain degree, Say was correct in doing this. "Numbers of our insects are yet undescribed."[16]

On June 27, eight students graduated at the second commencement of the Rensselaer School. Asa Fitch, A. B. (R. S.), returned to Salem, happy and inspired by his unusual experience at the novel school for scientific education.

REFERENCE NOTES

[1] S. Rezneck, *Education for a Technological Society: A Sesquicentennial History of Rensselaer Polytechnic Institute* (Troy: Rensselaer Polytechnic Institute, 1968), p. 50 (hereafter cited as Rezneck, *Education*).

[2] *Ibid.*, pp. 50-51.

[3] Asa Fitch Diary, 18 Sept. 1826, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University (hereafter records from the Fitch Diary are cited as Diary, followed by the date of the record).

[4] *Ibid.*

[5] *Ibid.*, 4 Oct. 1826.

[6] *Ibid.*, 10 Oct. 1826.

[7] *Ibid.*, 11 Nov. 1826.

[8] Rezneck, *Education*, p. 52.

[9] S. Rezneck, The religious life and struggle of a New York scientist, 1809-1879, *New York History* 53 (1972): 411-436.

[10] Diary, 1 July 1827.

[11] *Ibid.*, 12 Oct. 1826.

[12] *Ibid.*, 31 Oct. 1826.

[13] *Ibid.*, 23 Feb. 1827.

[14] *Ibid.*, 15-17 Mar. 1827.

[15] *Ibid.*, 24 Mar. 1827.

[16] *Ibid.*, 7 Apr. 1827.

CHAPTER FIVE

Medical Education

Asa spent the remainder of the summer of 1827 at home reading, reflecting upon religion and collecting insects, plants, and minerals. He scolded himself, "I must not idle away my time." The 18-year-old graduate admitted, "This if ever is the period of my life when knowledge must be rapidly accumulated." He also felt that religion should receive a greater share of his attention. "I have been truly negligent on this subject . . . The little knowledge which I have of Heaven & eternity has been mostly picked up as collateral, while some other subject was my grand object . . . My daily walk & conversation exhibits little – almost nothing of the Christian. It is lamentable! I pity myself when I reflect upon it. I must do better. I *must* do better."[1]

Asa followed family tradition and began studying medicine. He was guided by his cousin-in-law, Dr. Alfred Freeman, who had purchased the senior Asa's medical practice in 1820. His plan was to study as an apprentice to Dr. Freeman until winter lectures started at the Vermont Academy of Medicine in Castleton, about a day's ride from Salem. In those early days of American medical education, the conventional requirements for a degree of Doctor of Medicine included three continuous years of study under a licensed medical practitioner so that the student could learn the practical, clinical aspects of the profession. The student also was required to attend at least two, two- to three-month sessions at a chartered medical college to learn the more theoretical aspects of medicine. He could graduate after presenting a satisfactory dissertation on some medical subject and passing comprehensive oral examinations.[2]

When Asa started to study under Dr. Freeman in July of 1827, he prescribed for himself a rigorous schedule – to arise with the sun, study natural history until breakfast, and then repair to Dr. Freeman's shop to study anatomy for several hours. He spent the evenings at home reading and writing. Asa hoped that after his first term at the Academy he would be sufficiently prepared to lecture on science to the Washington County medical students. His father, then president of the County Medical Society, had proposed that the Society purchase "chemical and philosophical apparatus" and put it in Asa's care if he would lecture every week or two.[3]

It probably was easy for Asa to choose a medical college. Castleton was nearby, and, although certainly no bustling metropolis, it was an early center of communication, prosperous and cultured.[4] The Academy had an excellent reputation among country medical colleges in America. The respected faculty included the familiar Professors Eaton and Beck from the Rensselaer School. Some classmates from the Rensselaer School also attended Castleton.[5]

On September 2, Asa left Fitch's Point for Castleton, arriving early the next day. He looked over the village, found lodging and board for $1.50 per week, and spent some time looking for insects and making geological observations.[6] On September 5, he enrolled in the Vermont Academy of Medicine and attended the introductory lecture of the term, delivered by Dr. Lewis C. Beck to a "motley collection" of persons in a well-filled room. The subject was the importance of natural history to medicine.[7]

Throughout the term, lectures were given six days a week, without holidays or vacations, the usual program including five lectures daily.[8] The Academy's curriculum during that era included topics ranging from botany to diseases of women and children. At the beginning of Asa's first term, Dr. Beck, Dr. Theodore Woodward, and Dr. William Tully lectured. Dr. Beck, one of the renowned Albany medical brothers and a noted educator and researcher in chemistry, botany, mineralogy and geography, was engaged by the Academy from 1827 to 1833 to teach chemistry and natural history. Dr. Woodward, one of the founders and a principal administrator of the Academy, and a successful surgeon and excellent teacher, taught surgery, obstetrics, and diseases of women and children from 1824 to 1838. Dr. Tully, a voluble lecturer who helped establish the Academy's high reputation, taught medicine and medical jurisprudence from 1824 to 1829.[9] Late in October, Dr. Jonathan Adams Allen took the place of Dr. Beck. He taught materia medica and pharmacy at the Academy from 1823 to 1829, but was then dismissed for neglecting his teaching duties. Professor Eaton arrived to lecture on natural philosophy, and Dr. Alden March, a brilliant teacher who became president of both the New York State Medical Society and the American Medical Association, and founder of Albany Medical College, arrived to lecture on anatomy.[10]

Asa, of course, was busy taking notes at the lectures, although, characteristically, he himself was dissatisfied by his occasional inattention and by what he saw as his lack of progress. Spare moments were spent transcribing notes, which he may have taken using a system of stenography learned during the summer by copying articles on zoology in preparation for the Castleton lectures.[11]

On the evening of October 18, a fellow student, Jonathan Chandler, invited Asa to join some other students dissecting a cadaver before Dr. March arrived. With a great sense of secrecy the two students contrived a means to escape the suspicions of Asa's roommates about his absence. At the college, the clandestine party withdrew to the dissecting room, their light hidden under a cloak. In the early nineteenth century, medical colleges found it a perplexing problem to legally obtain human bodies for dissection and demonstration purposes, so illegal procurement was extensive. The bodies were often obtained surreptitiously at night from some country burial ground. After the Champlain Canal was completed in 1822, providing a connection between the Hudson River and Lake Champlain at Whitehall, many bodies in barrels of brine marked "pork" were shipped by canal boat from Albany and Troy to Whitehall, then by wagon to Castleton. They were consigned to a merchant in Castleton who was also a trustee of the Academy.[12]

As early as 1824 students of the Academy in Castleton were arrested on charges of alleged grave robbing. Because local residents were constantly suspicious, dissection by students was done rapidly by a small group before the body deteriorated. A sense of secrecy and urgency accompanied such scenes because a search by a constable was a constant threat.[13]

Asa entered the dissecting room with trepidation. He recorded the scene in his diary:

> And when the face of the subject was uncovered I sunk back from the dreadful sight, shuddering at the recollection that I had gone there for the purpose of seeing them [*sic*] pallid features lacerated & dispoiled [*sic*]. The sunken eye sockets, in which the mould was already gathering, & the colourless, but fair countenance, which in a few years might have been matured in the bloom & beauty of youth continually haunted my mind. And the crimson nails which terminated the little fingers, carried the imagination to that time when the colour first settled there, & the agony, which rent the mother's bosom, as she watched the departure of her dear child. But these feelings gradually wore away. The rest of our company came, & before the evening's work was ended I could almost look upon the face without emotion. My improvement in the mean time I hope compensated me, for the dread which was first sent to my heart.[14]

Four days later Asa for the first time "took the knife, & laid open the integuments of the thigh." He no longer felt afraid upon entering the dissecting room, "though I should not dare to attempt it alone."[15]

During the latter part of the session at the Academy, Asa tried to correct his habit of using tobacco. He had been using it ever since his second summer at the Washington Academy in Salem. Having realized his addiction to smoking during the winter in Bennington, he had decided to throw his pipe into the fire and begin chewing. While working at the store in Salem, both smoking and chewing were in vogue, but on the Erie Canal expedition smoking was inconvenient and unfashionable, so he once more abandoned it. Asa was now resolved to abandon chewing. "A little smoking, that the change may not be too sudden, & I hope to be thoroughly reclaimed." On November 23, his last quid was finished. "What! unable to overcome any habit! I hope not."[16] A week later he was still longing for tobacco and feeling "half dead." ". . . My mouth must be in the right tone, for me to take any comfort." Asa purchased more tobacco. "Oh the happiness of tasting the fumes of the Indian weed!"[17]

On December 11, Asa departed for Salem, intending never to return to Castleton, where he was unhappy with his progress as a medical student, but sufficiently impressed by the Academy. On Christmas Day he somewhat reluctantly went to a party, wishing not to be labelled "a sober old deacon at all times." He was a vigorous young man of 18, weighing about 155 pounds and standing 5 feet 11 inches tall, but parties were a new experience for him.[18] A morally rigorous background dictated that this pastime was improper. Asa had not been kissed since childhood, ". . . but here was — none too much of it." He even took four swallows of brandy, much more than he had consumed the past two years. A religious struggle became evident as he rationalized his involvements in the amusements at the party. "The time spent in them is a chief objection to them I think, & not any sinfulness that there is in them." In the end, he decided that time must be taken to form acquaintances.[19]

For the next several months Asa remained in Salem, studying medicine under Dr. Freeman. He again resolved to spend six hours a day for the rest of the winter reading medical books.[20] For the first time, he was called upon in a professional capacity — to see if he could do anything for a

Mrs. Marble's "Hysterical, Spasmodical fit." He immediately sent for Dr. Freeman's able council, and the Doctor prescribed "Carb. Ammon., Tinct. Opii – Castor, & warm tea, & bleeding."[21]

Asa experimented with the effects of nitrous oxide, also known as exhilarating or laughing gas. This may appear to have been a self-indulgent lark, but in fact it was probably conceived as a practical exercise in self-instruction for a young medical student. When inhaled, the gas reduces sensibility to pain after an initial period of exhilaration, and it is used as an anesthetic. Assisted by a fellow student, William Savage, Asa made the gas and went to a field below Dr. Freeman's shop to inhale it. Before his witnesses, William and Edwin Thayer, Asa began laughing heartily. He found the sensations agreeable, even ecstatic, and speculated that they would have been more so had a larger quantity been used. The next day, the two students made more gas, and with "half the neighborhood" looking on, Asa "jumped & ran, & slapped my hands & halloed, & once exclaimed 'Happiness'. . . ."[22]

As the summer of 1828 passed, Asa was pleased to observe that his bashfulness and timidity, prominent traits in earlier years, were quickly waning. He was becoming more worldly. On October 16, at an "apple pairing [*sic*]," he danced for the first time, but only after much entreaty. He soon found himself making arrangements for a ball to be held on the evening before his departure for New York City, where he would attend a term of lectures at Rutgers Medical College. Objections arose in the small puritanical community. "But, mercy on us! What would folks think, for me to go & bring in a load or two of girls, to dance. . . !"[23] Nevertheless, Asa was determined to succeed despite all the unfavorable circumstances. Two or three times in the past people had attempted to have a ball on the Point, but without success, and most people seemed to think that it was impossible to do. Asa was worried that his party might fail, thus making him look like a fool. "Calm thoughts are now strangers to my brain. I am as restless as the bark upon the ocean's waves." To make matters worse, Asa's father had heard about a dance or ball being planned and advised his son not to attend, unaware that he was at the bottom of it all.[24]

On the appointed day, October 29, Asa went to his room to dress in his finest clothes, then left the house without uttering a word to any member of the family and made rounds to pick up the young ladies who had been invited to attend the ball. He was ecstatic that so many had decided to attend. "Oh happiness! happiness! After so much fear & anxiety, & depression of spirits, how did I not feel, when all things were going on equal to my most ardent wishes – exceeding my most sanguine hopes." Upon arriving at the ball after picking up a second load of girls, he found a greatly enlarged crowd. "How did my heart dilate with joy . . ." A fiddler entertained 17 ladies and 20 gentlemen. Asa was pleased with his progress in dancing – and the party in general.[25]

At breakfast the following day, Asa was questioned about the circumstances of the party and received advice to refrain from such assemblies.[26] He then started for New York City. On board ship from Albany he met Dr. Ebenezer Emmons, who had studied science under Amos Eaton and Chester Dewey at Williams College and graduated with the first Rensselaer School class in 1826. Emmons was on his way to New York to assist John Torrey at the College of Physicians and Surgeons, Rutgers' rival school. Dr. Torrey had been Professor Eaton's botanical comrade while the latter was in prison. Like Eaton, he was adept at devising apparatus to illustrate his lectures. Torrey was a renowned professor of chemistry, but history would remember him best for his botanical avocation. In 1820 he graduated from the College of Physicians and Surgeons and in 1827 was appointed to the chair of chemistry, a post he held until 1854.

Rutgers had been founded only about two years earlier by a group of distinguished physicians and lecturers from the College of Physicians and Surgeons. Disappointed with differences and disputes they had with the trustees of the College over the division of fees, they seceded and founded its only competitor for the lucrative medical student fees in New York City. In their search for legitimacy they won affiliation with Rutgers College in New Jersey. By 1830, the new college would admit failure and cease operation, due largely to pressure from the older institution.[27]

At Rutgers, Asa joined a classmate from the Rensselaer School, George Horton, whom he described a decade later as his "dearest and most esteemed earthly friend."[28] They shared a crowded room with two other students.[29] The opening lecture, on forensic medicine, was given November 2, 1828. Thus began a busy four-month visit for the country boy in the expanding city of New York. Asa soon built up a full schedule of medical study at Rutgers – one that included lectures on such subjects as materia medica and anatomy, and others typical of an early medical education. The distinguished faculty included Drs. Hosack, Francis, MacNeven, Mott, and Bushe. Asa spent his days attending lectures and visiting the wards at the nearby hospital; his evenings were filled with the endless task of writing and transcribing notes. He sometimes sat up as late as one or two o'clock, aided by an opiate, and eventually he was overcome with eye trouble.[30]

Asa took Dr. Bushe's lecture ticket for anatomy and joined his private class in dissection. Dr. Bushe, an Englishman who had just been appointed on the recommendation of London's leading medical men, was guaranteed the then princely sum of $2600 for four months of lecturing.[31] Asa's experiences at the hospital and in Dr. Bushe's dissecting room filled an especially noteworthy place in his medical education. He was able to witness many operations and dissections, an opportunity far less available at the country medical school in Castleton.

At noon on November 29, when Asa went to the hospital as usual, his callousness was unexpectedly tested and found wanting. He watched Dr. Steven perform an amputation of a man's left leg, about half way between the knee and ankle. The affliction was "caries of the os. calcis." The operation provoked an emotional reaction from Asa. "To behold the keen shining knife drawn round the leg severing the integuments — to see these dissected up & folded over, while the unhappy subject of the operation uttered the most heart rending screams in his agony & torment — to see another stroke of the knife cut through the muscular calf of the leg to the bone — & to hear the saw working its way through the bone, produced an impression I never can forget." Asa found it difficult to look on, and he covered his eyes to keep from fainting. "A momentary glance was all I could bestow, & with my eyes averted, I would wail till I had collected strength enough for another look, equally brief, & I was rejoiced when it was through."[32]

Despite his busy schedule of medical studies, Asa found time for diversion — and many tests of his rigorous religious and moral background. Sundays were occupied with visiting the churches, sometimes more out of curiosity than a sense of religious fervor.[33] Museums and the theater provided entertainment. As an ardent collector of books and an admirer of romantic tales and poetry, he attended many book auctions, and despite rigid economy he acquired volumes on subjects ranging from medicine and science to poetry.[34] Contrary to earlier resolutions, he drank heavily on Christmas Day to relieve the loneliness of life in the city.[35]

Late in November, Asa joined a dancing class. The instructions concerned the behavior of polite society more than expected, so this country boy decided he would learn how to bow and shake hands to the utmost of etiquette.[36] He attended classes regularly, even when ill, and occasionally used opium to stimulate his "dancers."[37] Although worried about the opinions of folks back home concerning the supposed sinful character of dancing, Asa derived great pleasure from the gaiety and frivolity — and his newly acquired knowledge of the manners and customs of city life.

As the year 1828 came to a close, Asa reflected upon his progress toward the age of manhood. Worried about a natural diffidence and bashfulness, he decided that much success and character as a physician depended upon being free and composed in the company of strangers. Having taken a fancy to the fairer sex, he resolved to mix more with neighbors and friends and acquire the art of conversation. "My proficiency has been great, but not so much so, as more resolution, & a natural faculty for abstract thought, would have made it. . . . But time will carry me forward to the mark at which I aim, & had I the ready command of ideas & language with which many are endowed, my progress would be much facilitated."[38]

In February, Asa returned to Salem and again studied medicine under Dr. Freeman, with whom he was disappointed because the Doctor did not take his students out to see enough practice. Of course, Asa also pursued natural history. In August he discovered an old edition of Linnaeus' *Systema Naturae* in the library of some medical acquaintances. He regretted not having known about it earlier because by now he would have had part of it translated and, doubtless, would have found the correct names for many insects.[39] After a summer of medicine, science, and social diversions, he departed again for a term at the Vermont Academy of Medicine, although he had already made up his mind not to return to Castleton and, in fact, had made plans to meet roommates from New York City at the Medical College of the University of Pennsylvania.[40] On August 26, he left, determined not to make Salem a home until finished with medical school, and perhaps not even then.[41]

At Castleton, Asa resumed the long schedule of lectures, which quickly became tedious, and he became homesick and melancholic. His schedule soon became so reduced that he wondered if it was worth staying, until he thought to himself, "But the dancing school, ah yes, I will stay . . . for what more do I want." [42] He continued to experiment with drugs, inhaling ether and consuming opium, all in the supposed interest of self-edification. Involvement with a debating society offered an opportunity to study "Ladyology."[43] Of course, Asa attended church regularly and continued his interest in natural history. On a countryside walk he saw a species of wasp, ". . . black, shining, the middle of its antennae white. Lovely insect! May I yet contribute to bring thy species to the knowledge of the world! I had almost declared '*I will — I will do it*.' "[44]

Asa's loneliness became burdensome. "Oh then what ecstasy would attend this period of my life, if passed 'in my native valley.' But now I feel more like getting a name & a fame, & making me a home where nature did not apparently design it — where congenial feelings may be gratified. But these are too much like the musings of a melancholic. Oh, may it ever be my lot, to be contented — to be happy, in whatever sphere I may be placed, nor pine away my life, with needless gloomy thoughts, when at best there is sorrow enough."[45]

Finally, late in November, Asa became overly weary of the lectures. His three-year course of medical study was supposed to last until July, but he decided to apply six months of his Rensselaer School education toward the medical degree, and he applied for degree candidacy.[46] Lectures ended on December 1, and Asa submitted a dissertation on the relationship between the natural sciences and medicine.[47] On December 4, he underwent oral examination, and on December 8 the students read their dissertations. Asa's was readily approved. He noted that the last dissertation read was on "Fecundation, & a nastier, & more disgusting piece could scarcely have been composed." Apparently, every movement and appearance in the act of copulation was minutely described, and the professors and students shook with laughter.[48]

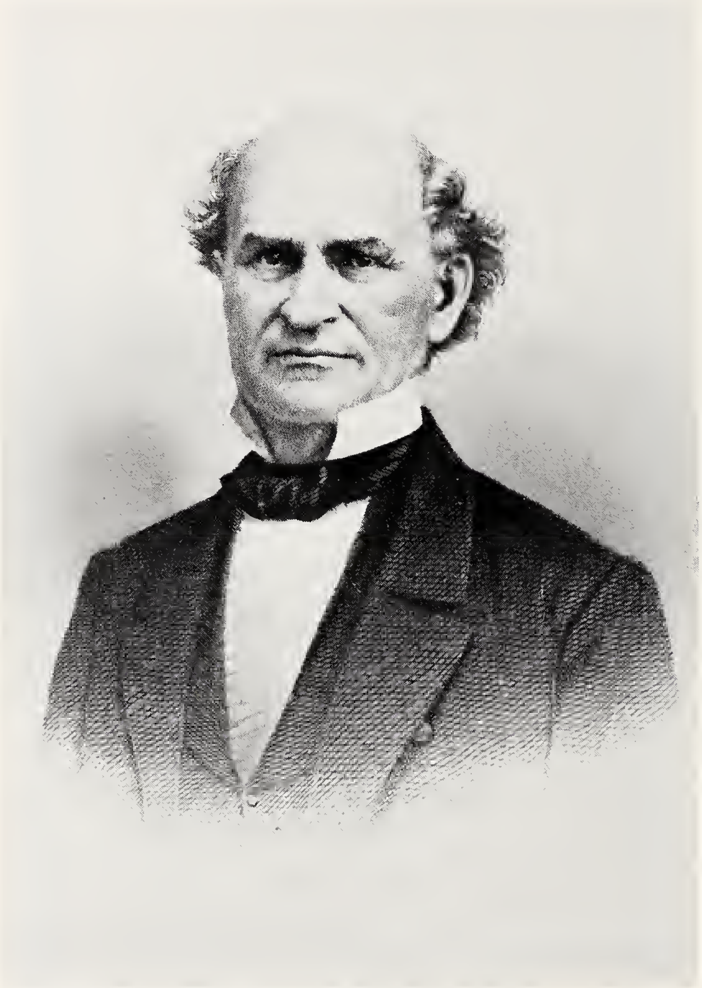
The next day, Asa Fitch received the degree of Doctor of Medicine. He packed, said goodbyes, and boarded the stage with other students. For some distance at short intervals they all sang out in full chorus, "So fare thee well, old Castleton, I ne'er shall see you more."[49]

Shortly after returning to Salem, Asa's father again objected to his attendance at dancing lessons, but the young doctor was not about to give them up. He was determined to shake off the diffidence and timidity, the "say-nothing-to-nobody-ness," that had plagued his youth. It would never do for a doctor, and he was resolved to cure himself by socializing so he would not be regarded as an "ill bred booby." He was satisfied that dancing lessons had helped him attain this goal with no moral damage.

> I can now go into company, yes, & polite company, & feel myself at home. . . Let any one compare me, as I was two years ago, & as I now am, & judge if I have not gained infinitely & at a cheap rate. I am satisfied with myself. . . I have danced. I have played. I have kissed rosy cheeks. I have won maidens' smiles. Yet I do not think I have gone astray, or opened the wounds of my dear Saviour afresh, or sinned deeply against my God. I have not caroused. I have not drank [*sic*] the intoxicating draught. I have not taken my Maker's name in vain. And if dancing is to be condemned from the vicious habits to which it leads, I can aver that I have never felt this tendency. I have not gambled. I have not squandered away money. I have had no illicit connections. I have not even had any such inclinations. Never, no never.[50]

On Christmas Day, at a conference held by the First Presbyterian Church, the Reverend Mr. Tomb and the senior Asa Fitch were appointed to discuss the young Dr. Fitch's refusal to renounce dancing. Dr. Fitch decided to withdraw from membership in the Presbyterian Church if he were told to stay away from the communion table.[51] The day after New Year's Day, his father told him he must not receive communion. He considered joining the Episcopal Church in Albany, where he was preparing to go to attend the private medical classes conducted by Dr. March.[52]

On January 11, 1830, Dr. Fitch heard Dr. March's introductory lecture. He spoke about his proposal to establish a medical school and hospital in Albany, a hope realized several years later. Dr. Fitch remained in Albany for about three months, taking advantage of the city's cultural institutions and using their facilities to further his knowledge of natural history. At the Albany Academy he visited Dr. Beck, who labelled his plants. Dr. Fitch also noted a few works on entomology in the Academy's library, particularly Samouelle's *Entomologist's Companion*, from which he copied material on the Linnaean genera.[53] At the State Library he examined Say's *American Entomology*; pleased with it, he decided to try copying some of the work.[54] Back at the Academy's library Dr. Fitch discovered Say's descriptions of insects in the *Transactions of the American Philosophical Society* and perused Blumenbach's *Natural History*. "Oh, I must take some of these out, & must go up there & copy others. I shall then (with copying at the State Library) have all that is known of American Insects."[55]



Dr. Alden March (Courtesy New York State Library).

One evening Dr. Fitch went to the Albany Museum, the private enterprise of one Mr. Trowbridge, to see a ventriloquist named Nichols. Here something excited his imagination:

> The upper, Natural History department . . .made me more longing & covetous than anything I have seen for some time. I saw a most superb green butterfly, among a countless number of insects, which I almost wanted to break through the glass and take sans further ceremony. But that would be stealing, so I thought of purchasing it. But I have no money to spare, so how shall I get it? Well, I have half a mind to strike a bargain with Mr. Trowbridge, to label his specimens "on the shares" by which means, I should obtain a good knowledge of Entomology, & secure to myself a most superb collection – though it would take up considerable time; but I intend to spend no small proportion of my life in this study. Wait till I have been here 3 or 4 months & then see.[56]

Dr. Fitch also found time to go to Troy to visit with Professor Eaton, from whom he learned something about entomology. He was glad to find Eaton a staunch supporter of the Linnaean genera. He found the more recent arrangements to be nothing more than confusion heaped on confusion and that every new writer rendered this "confusion worse confounded." "Books on books are added, each varying from its predecessor, *ad infinitum*; & the young Entomologist will find no pleasure in pursueing [*sic*] his favorite science, till he takes the system unadulterated of the Prince of Natural History, The immortal Linneus [*sic*]."[57]

Albany Academy (Courtesy New York State Library).

On February 24, 1830, Dr. Fitch observed his twenty-first birthday. He had made up his mind to go west, to Illinois. "My first enquiry when hunting up a place shall be 'how many balls & parties have you had the past week.' And all I ask is to make enough by day to spend by night. Oh, that will be the golden age of my life."[58]

On March 19, Dr. March gave his last lecture. Dr. Fitch then spent some time copying entomology, and on the way back to Salem again visited Professor Eaton in Troy.[59] He was interested in accompanying the upcoming Rensselaer School flotilla from New York City to Lake Erie and saw the expedition as an opportunity to begin the intended westward journey.[60] In Salem he collected insects, which were by now one of his chief objects of study.[61] Dr. Fitch had further disagreement with the Rev. Tomb, who refused to give him a certificate of standing in the Presbyterian Church because of his refusal to renounce dancing.[62] On June 4, Dr. Fitch received a letter from Professor Eaton, informing him of his appointment as Assistant Professor of the Rensselaer School, "if the honor of the station will be sufficient compensation." He concluded, "I think it will."[63]

Reference Notes

[1] Asa Fitch Diary, 8 July 1827, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University (hereafter records from the Fitch Diary are cited as Diary, followed by the date of the record).

[2] F. C. Waite, *The First Medical College in Vermont, Castleton 1818-1862* (Montpelier: Vermont Historical Society, 1949), p. 116 (hereafter cited as Waite, *Castleton*).

[3] Diary, 29 June 1827.

[4] Waite, *Castleton*, p. 23.

[5] S. Rezneck, The study of medicine at the Vermont Academy of Medicine (1827-29) as revealed in the *Journal of Asa Fitch*, *J. Hist. Med. & Allied Sci.* 24 (1969): 416-429.

[6] Diary, 3-4 Sept. 1827.

[7] *Ibid.*, 5 Sept. 1827.

[8] Waite, *Castleton*, p. 117.

[9] *Ibid.*, pp. 183-189.

[10] Diary, 25 Oct. 1827.

[11] *Ibid.*, 4 Aug. 1827.

[12] Waite, *Castleton*, pp. 123-124.

[13] *Ibid.*

[14] Diary, 18 Oct. 1827.

[15] *Ibid.*, 22 Oct. 1827.

[16] *Ibid.*, 23 Nov. 1827.

[17] *Ibid.*, 1 Dec. 1827.

[18] *Ibid.*, 10 May 1828.

[19] *Ibid.*, 25 Dec. 1827.

[20] *Ibid.*, 3 Jan. 1828.

[21] *Ibid.*, 18 July 1828.

[22] *Ibid.*, 6 June 1828.

[23] *Ibid.*, 27 Oct. 1828.

[24] *Ibid.*, 28 Oct. 1828.

[25] *Ibid.*, 29 Oct. 1828.

[26] *Ibid.*, 30 Oct. 1828.

[27] S. Rezneck, A course of medical education in New York City in 1828-29: the journal of Asa Fitch, *Bull. Hist. Med.* 42(1968): 555-565 (hereafter cited as Rezneck, Course).

[28] Diary, 16 Aug. 1839.

[29] *Ibid.*, 3 Nov. 1828.

[30] *Ibid.*, 16 Jan., 27 Nov., 10 Dec. 1829.

[31] Rezneck, Course, pp. 559-560.

[32] Diary, 29 Nov. 1828.

[33] *Ibid.*, 4 Dec. 1828.

[34] *Ibid.*, 7 Nov., 11 Nov., 2 Dec. 1828.

[35] *Ibid.*, 25 Dec. 1828.

[36] *Ibid.*, 21 Nov. 1828.

[37] *Ibid.*, 19 Jan., 13 Feb., 18 Feb. 1829.

[38] *Ibid.*, 31 Dec. 1828.

[39] *Ibid.*, 18 Aug. 1829.

[40] *Ibid.*, 19 Feb. 1829.

[41] *Ibid.*, 26 Aug. 1829.

[42] *Ibid.*, 23 Oct. 1829.

[43] *Ibid.*, 14 Oct. 1829.

[44] *Ibid.*, 10 Oct. 1829.

[45] *Ibid.*, 23 Oct. 1829.

[46] *Ibid.*, 30 Nov. 1829.

[47] *Ibid.*, 1 Dec. 1829.

[48] *Ibid.*, 8 Dec. 1829.

[49] *Ibid.*, 9 Dec. 1829.

[50] *Ibid.*, 11 Dec. 1829.

[51] *Ibid.*, 25 Dec. 1829.

[52] *Ibid.*, 2 Jan. 1830.

[53] *Ibid.*, 14 Jan., 16 Jan., 13 Feb. 1830.

[54] *Ibid.*, 15 Jan. 1830.

[55] *Ibid.*, 13 Feb. 1830.

[56] *Ibid.*, 22 Jan. 1830.

[57] *Ibid.*, 17 Feb. 1830.

[58] *Ibid.*, 5 Mar. 1830.

[59] *Ibid.*, 19-20 Mar. 1830.

[60] *Ibid.*, 1 Apr. 1830.

[61] *Ibid.*, 7 Apr. 1830.

[62] *Ibid.*, 20 May 1830.

[63] *Ibid.*, 4 June 1830.

CHAPTER SIX

To the Western Frontier

Dr. Fitch quickly prepared for the second expedition on the Erie Canal. On June 15, 1830, he went to Dr. Freeman's house, where he obtained a highly laudatory recommendation and copied information about the mode and amount of medical charges. He also selected shells and minerals to take west.[1] The next day he got a recommendation and some good advice from Dr. Proudfit and took his "interview finale" with his dear friend Clarinda Taggart:

> Oh, Clarinda Taggart, my business in this line, is now done, with you, forever. My lips have come in contact with yours, times *& ways* without number; & for 3 years, my hours of glee have generally been shared with you. But they are now all gone; fled forever! Well, your charms will never be obliterated from my memory, with whatever faults they may be blended.[2]

On June 17, Dr. Fitch arrived at the Rensselaer School only to learn from Mrs. Eaton that the Professor had started for New York about an hour earlier. Disappointed, he considered steering directly for the West but, instead, decided to stay in Troy for a few days. His father contributed $100 toward travel expenses, the last money he thought he would ever receive from his parents. It was enough for the journey to Galena, without stopping to raise funds by popular lecturing.[3] Dr. Fitch spent time at the Rensselaer School copying entomology from Rees' *Cyclopedia*, and on June 21 boarded the steamboat *New Philadelphia* for New York. Apparently, it was an uncomfortable journey:

> There were sundry noises constantly sounding in this ear, & sundry others, of a different kind, but equally loud, in *that* ear. These divers sounds, passing up my auditory nerves, & meeting formed a kind of nameless something, I cannot tell what – but it kept me awake till – till I dropped to sleep . . . Oh, I was ready every moment to jump on the explosion of the boiler, of which, judgement could not persuade fancy, there was no danger. The letting of the steam, made me fear & tremble – that sharp whizzing! Enough! How could I sleep. But I dozed again. Then a stick of wood would fall heavily on the deck. Heigho! That was the boiler. I could not endure it! So I got up. Took coat & boots in my hand, & fled from this place of terror, into the aft cabin, where I drew them on.[4]

In New York, Dr. Fitch met Professor Eaton and several others, and the Rensselaer School flotilla started up the Hudson River on the steamboat *General Jackson*.[5] Along the way they took in the sights and studied natural history. At West Point, Dr. Fitch heard Professor Eaton telling a Mr. Brown and other gentlemen that the assistant professor was "the best Entomologist – knew the most Insects of any one in U. S." Dr. Fitch denied it, but Mr. Brown advised him to write an essay for publication on the importance of entomology and to argue for the science's cultivation. Dr. Fitch told Brown he believed he should study in youth and publish in mature life.[6]

By the end of June the group was back at the Rensselaer School, and on July 1 the flotilla got underway on the Erie Canal on a boat named the *Surprise*. The students were anticipating a pleasant tour in which they would fill their natural history cabinets with a variety of elegant and valuable specimens and their minds with practical knowledge. At the locks at Cohoes Falls, Dr. Fitch left the boat and walked on, insect net in hand. He rejoined the boat further on.[7]

Dr. Fitch remained with the flotilla only a few days; he quickly became weary of the students' jealousy and quarrelsomeness.[8] Disappointed because of Professor Eaton's illness and inability to continue the trip, he decided to leave the boat in Utica, where he collected insects, attended church, and taught botany at the Utica High

School. He was offered $20 plus room and board to take over a botany class for three weeks, but accepted only $15. Among the teachers who were prominent at the school were Fay Edgerton, a graduate of the Rensselaer School, and Asa Gray, the botany instructor, who later, as professor of Botany at Harvard, earned world reknown. One of the students in Dr. Fitch's class was James Dwight Dana, who would go on to become a member of the Wilkes expedition, a professor at Yale, and one of America's early scientific giants, particularly in the fields of geology and zoology.[9]

Dr. Fitch visited many churches and heard stirring remarks while in Utica. One Sunday a Mr. Edward Beecher, an agent of the American Sunday School Union, spoke on the proposed effort of the Union to establish Sunday schools throughout the Mississippi Valley. These remarks went to the bottom of his heart, and his emotions were so strong that tears gathered in his eyes as Mr. Beecher told of the ignorance and moral waste in the Valley. ". . . I felt every fibre of flesh creeping on my bones. Oh, I shall go there, & I shall *act*. . . ."[10]

On August 3, Dr. Fitch had his boxes addressed and loaded onto the boat *Mobile*, of the New York and Ohio Line. His diary reveals that he reflected upon the exciting adventure before him:

> And now I was again gliding over the *long, long canal*, full of the ardent hopes of youth; now I was anticipating a long but pleasant journey, through one of the loveliest countries on the face of the earth, this moment looking upon the most beautiful & picturesque of nature's rural scenes, the next upon those on whose features grandeur & sublimity is impressed; now I was journeying to the "far west regions" of Missouri, Illinois, & Michigan, thousands of miles beyond where my feet have ever trod before; now I was to go along the most stupendous canals, rivers, & lakes of the new world, to the *Eden* of my native country – the El Dorados of America – whose mineral stores are inexhaustible, whose fertile soil is unparalleled, where banks of wild flowers ever varying in colour, bloom from early spring to late autumn, to gladden my eyes, & employ my leisure hours in studying them – where rare insects of the richest & most splendid hues – from the rich golden, the polished coppery, to the glittering green, or the bright rose tints, are ever shooting through the air, or feeding on the gay flowers, to woo my mind, & deck my cabinet. Oh how my heart throbs with bliss, on anticipating my coming home. Let me *on, on*, fast as the powers of Equinus, Eolus, & Neptune – aye & *steam*, more powerful than all, can carry me. Let me see these scenes, feast my eyes with the sight of this Elysium, & my mind with investigating its new natural objects![11]

The boat was crowded with a heterogeneous assemblage of emigrating Scotch, Irish, Yankees, and a few others. All were travelling to western regions, many of them seeking homes in the wilderness, but none were going as far as Dr. Fitch.[12]

Dr. Fitch disembarked in Jordan, New York, to visit a delightful young lady from his home town, Emily Wheeler, whom he had not seen in two years. He dressed in the best of style and suppressed the shyness and timorousness of youth. Over breakfast, the couple discussed the subject of marriage, and Dr. Fitch told Emily he did not believe he would find a wife in Salem, Troy, or Castleton, that some of the western squaws stood the best chance, and, some years hence, she might expect him to stop in with a wife and two or three papooses while on a return trip to visit Salem. His true intentions, however, were to wait and see if he could support himself before marrying, "till my youthful passions were cooled, & my wild oats sown. . . ."[13]

Dr. Fitch continued westward, by canal, lake, river, and road, by canal boat, steamboat, stage, and horseback, passing through a cross section of a growing America: Buffalo, Ashtabula, Wellsville, Wheeling, Louisville, Shippingsport, Portland, and St. Louis. Of course, he collected insects along the way. Early in October, he arrived in Greenville, Illinois, poorer by $112. 46.[14] Greenville, the seat of Bond County in southwestern Illinois, was a small, crude, frontier community, not far from Vandalia and New Salem, where young Abraham Lincoln, the same age as Dr. Fitch, went in the same year, 1830, to start a career in a store. Thirty-five years later, Dr. Fitch would see the stricken president's remains in Albany, where the funeral car paused on its long, sad journey from Washington to Springfield. As bells tolled and cannons fired, Dr. Fitch would praise Lincoln, one of the greatest men he had ever seen.[15]

Dr. Fitch spent an unhappy winter in Greenville – one full of self pity. It was the "Winter of the Deep Snow," and living quarters were primitive. He boarded with the Berry family – "a school of scandal and laziness."[16] The air in the house was almost as cold as it was outdoors because the building was only weather-boarded, and there were wide cracks in the walls.[17] Dr. Fitch spent many hours before the fire twisting and turning, endeavoring to warm both front and back.[18] Frozen apples did not make up for a deficiency of warm food, and recurring fits of the ague did not help his temperament.[19]

Dr. Fitch had hoped to establish himself as a frontier physician and a teacher to spread the new Eatonian gospel of science in American education. Professional ambitions, however, were frustrated by the presence of another physician, Dr. Drake, and another teacher, Mr. Pierce. Dr. Drake occasionally called upon Dr. Fitch to take a case, but Drake was too surly for this to be a comfortable arrangement.[20] Mr. Pierce organized a school before Dr. Fitch could, and the young doctor from the East was coolly received by the frontier people.[21] Income opportunities were thus severely limited on the Illinois frontier.

Dr. Fitch took advantage of the slim opportunities that were afforded for religious, intellectual, and social interaction. Greenville needed a preacher, and Dr. Fitch went to hear the ones who visited the community.[22] He was active in the formation and functioning of the Greenville Polemical Society.[23] The members discussed themes like government sponsorship of internal improvements, the permanency of republics, and the abolition of slavery. Of course, Dr. Fitch returned to courting the ladies, but he was critical of the local girls.[24] He found their minds unrefined and uneducated — in one case, "a wilderness more dark than groves of fir on Huron's shore."[25]

For his favorite pastimes, literature and natural history, Dr. Fitch also found few opportunities. The frontier community was generally destitute of books, except for the Bible and the Methodist hymnbook, but there were opportunities to collect insects.[26] The budding entomologist must have seemed odd in the crude frontier setting, as this description by the Honorable Elmer Baldwin of Farm Ridge suggests:

> He wore a stove-pipe hat, the inside of the crown was well lined with entomological specimens, to which he added many during the day he spent with me. Some of the insects thus pinned to his hat were still alive and seemed to make very acceptable music for him. I learned much from him that I have never forgotten, and when he left I felt I had had a rich treat, and had parted with a man of very superior intelligence and knowledge.[27]

The western adventure that began with such high aspirations ended as a misadventure in March of 1831, after only a few months of unexpected illness and ill humor. Dr. Fitch returned to Salem as soon as weather permitted travel.

REFERENCE NOTES

[1] Asa Fitch Diary, 15 June 1830, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University (hereafter records from the Fitch Diary are cited as Diary, followed by the date of the record).

[2] *Ibid.*, 16 June 1830.

[3] *Ibid.*, 17 June 1830.

[4] *Ibid.*, 21 June 1830.

[5] *Ibid.*, 23 June 1830.

[6] *Ibid.*, 25 June 1830.

[7] *Ibid.*, 1 July 1830.

[8] *Ibid.*, 6 July 1830.

[9] *Ibid.*, 9-12 July 1830; M. M. Bagg (ed.), *Memorial History of Utica, N. Y., From its Settlement to the Present Time* (Syracuse, D. Mason and Company, 1892), Part 1, 632 pp.

[10] *Ibid.*, 25 July 1830.

[11] *Ibid.*, 3 Aug. 1830.

[12] *Ibid.*

[13] *Ibid.*, 5 Aug. 1830.

[14] *Ibid.*, Diary 5, "Table of Expenditures."

[15] Anonymous, Asa Fitch, M. D., goes to the funeral of Abraham Lincoln, *Bull. Entomol. Soc. Amer.* 11(1965): 8 (furnished by Arnold Mallis from the Fitch Diary, according to editor); Diary, 25 Apr. 1865.

[16] Diary, 25 Dec. 1830.

[17] *Ibid.*, 15 Dec. 1830.

[18] *Ibid.*, 20 Dec. 1830.

[19] *Ibid.*, 22 Dec. 1830.

[20] *Ibid.*, 8 Dec. 1830.

[21] *Ibid.*, 10 Dec. 1830.

[22] *Ibid.*, 19 Dec. 1830, 5 Jan., 9 Jan., 30 Jan. 1831.

[23] *Ibid.*, 6 Dec. 1830.

[24] *Ibid.*, 18 Dec. 1830.

[25] *Ibid.*, 25 Dec. 1830.

[26] *Ibid.*, 14 Jan. 1831.

[27] F. W. Goding, Three friends of New York agriculture, *Trans. N. Y. State Agric. Soc.* 50(1891): 358-366.

CHAPTER SEVEN

Back Home

Back home in Salem, Dr. Fitch participated in activities of the town lyceum and county medical society.[1] However, he wished he had nothing else to do but collect and describe insects.[2] Dr. Fitch was delighted and enthralled with the "French Encyclop. Manuels of Nat. Hist. & of Entomol." that Dr. Freeman had obtained for him, but he feared that family worship had now become tedious because of this new entertainment. In his room he stayed up until eleven o'clock, cutting apart the leaves in various places and gazing upon the rich feast before his eyes. He thought to himself, " 'The die is cast.' I am an Entomologist."[3]

In November, Dr. Fitch moved to practice medicine in the nearby village of Fort Miller, where he also became active in another lyceum and returned to courting. This time, he met the girl he would marry, Elizabeth McNeil, – "the very one whom I have picked out for my *belli-bon* this winter. On her I calculate to inflict my attentions. I like Julia for her beauty – the charms of her countenance – but Miss McN. for her mind."[4] He took part in setting up a dancing school, and his father, again objecting on religious grounds, threatened him with separation from the family's affection.[5]

On November 15, 1832, Dr. Fitch married Elizabeth McNeil, daughter of John McNeil of nearby Stillwater, New York. A more desirable opportunity for medical practice existed in Stillwater, so the couple moved there and soon started a family. In November of 1833 Elizabeth gave birth to a daughter, Sarah Elizabeth, and nearly three years later to a son, Charles Linnaeus. Dr. Fitch became deeply involved in the literary and scientific advancement of the community, instructing a class of young people in botany and actively participated in the Stillwater Lyceum, giving addresses on such topics as the importance of mental culture and the spirit of the times.[6] The latter address, which he had already delivered before the Salem Lyceum more than five years earlier, was given in January of 1837. It was an admirable exposé of the innocent, optimistic, and progressive American Victorian world in which he lived:

> The present age is peculiarly characterized by a remarkable excitement upon the various objects which attract the attention of mankind. Not only is this a correct proposition with regard to religion, morality, benevolence, & charity, but it applies in almost an equal degree to all other things with which we are concerned. Literature, science, the useful & the polite arts, everything which has hitherto engaged "the heart & the hand" of man, is at present prosecuted with a zeal & a success unparalleled [*sic*] in all former ages of the world . . . A spirit of inquiry & research is abroad, beyond all former parallel – a spirit which in many departments of science & the arts has achieved results truly astonishing – & which instead of being satisfied with past success, only burns with increased ardour . . . Are not those days of Millenial [*sic*] glory, predicted in the divine oracles, evidently drawing near?[7]

Dr. Fitch continued with a discussion of the astonishing new modes of transportation being developed. He spoke of the romance in the notion of a railway a thousand miles long, of the delight in overcoming distance by art, and of the dream of flying. He spoke about mass communication and its rapid advancement in the past 50 years, particularly the improvements in printing presses and the use of steam to power them. He also mentioned advances in chemistry, natural philosophy, and, of course, natural history.

> A half century has scarcely passed since the manes of the illustrious *Charles Linnaeus*, the prince of Natural Historians, were committed to the tomb. His philosophical investigations, his scientific arrangement, & perspicuous nomenclature

Dr. Asa Fitch (Courtesy Cornell University Libraries, Department of Manuscripts and University Archives).

Mrs. Elizabeth McNeil Fitch (Courtesy Cornell University Libraries, Department of Manuscripts and University Archives).

> of the innumerous subjects of the 3 kingdoms of nature, gave these sciences an aspect entirely new, beautiful, & attracting. Let us render homage to Linnaeus! He was the first who made the study of Nature as alluring, as fascinating to the mind, as its objects are to the eye . . . His Systema Nature [*sic*] . . . strange as it may seem, contained brief descriptions of all the species of natural objects known in his time, amounting to upwards of 50,000 in number, & yet so perfectly arranged, that with a few minutes labor, any one species might be determined, having the specimen of it before us.
>
> Natural History, & particularly Botany, has been a favorite study from that day to this; & the number of its species at present known, described, & arranged upon the plan of which he is the author, amounts to upwards of 150,000 . . . New species, & even new families, are daily adding to this number.[8]

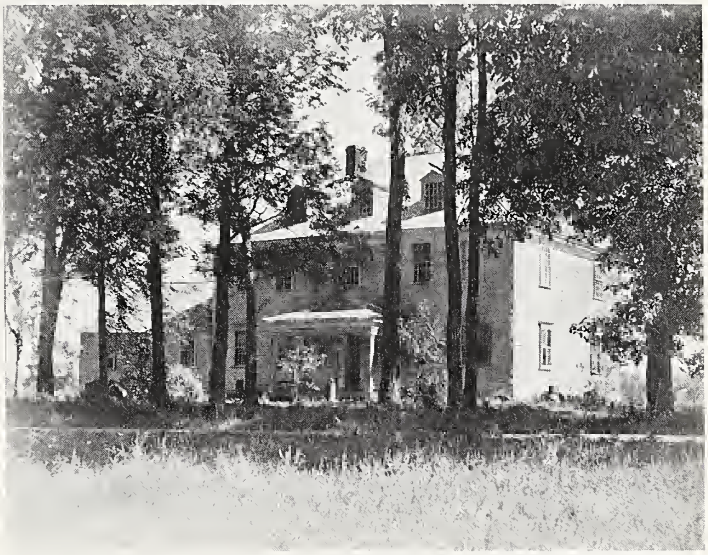
In Stillwater, Dr. Fitch energetically pursued spiritual and moral interests as well. He was elected an elder in the Presbyterian Church and served as its clerk and usual representative at higher church meetings. He joined the Stillwater Temperance Society and encouraged the drinking public to take the temperance pledge and use the "cold water cure" for drunkenness. Although he had been involved in the sale of demon rum while assisting at the general store in Salem, by 1833 Dr. Fitch was happy to declare that he would rather beg for food than obtain money from the sale of liquor.[9]

It might have been during this period that Dr. Fitch became involved with a society known as the Jolly Club. Its purpose was to occupy leisure evenings in relating tales and singing songs for amusement. "Begone dull care" was the club's motto. Alternatively, as called upon by the chairman of the evening, the members took their respective parts in the exercises. A standing rule dictated that if any member refused to tell a story or sing a song when called upon, he must sit on the dunce block for the remainder of the evening, and all the other members were to turn and grin at him every five minutes. Because of this severe penalty, few failed to take part when called upon. To become a member of the club, candidates had to relate a tale that kept everyone laughing for at least five minutes. Members were not allowed to snore unless the tale being told was insufferably dull.

And the Jolly Club, in the Jolly Club,
Be civil dear bub, or you'll get a snub,
A snub, or a drub, or a rub-a-dub-dub.
Hurra! hurra for the Jolly Club![10]

Late in 1837, Dr. Fitch realized that a return to Salem was imperative. His father was aging and unable to attend to business and the family estate, and his brother James, who was not getting along with the elder Fitch, had decided to build a house on another part of the farm. In a letter to his brother, Dr. Fitch admitted to prospects of being a sorry sort of farmer until a few years of schooling familiarized him with the business. He worried that the local medical business would be small because the local inhabitants had all employed other physicians since 1834, when Dr. Freeman moved to New York City, where he became a homeopathist and acquired a fortune from his extensive business.[11] Furthermore, Stillwater offered Dr. Fitch many conveniences and good friends. However, he faced his predicament with characteristic philosophical optimism. It seemed that Providence had directed Dr. Fitch's return, and he acquiesced. He decided to go home in the spring of 1838 with a firm determination to promote harmony and friendship in the family. He recollected the thousands of incidences in life that cause pain and misery and felt it was unthinkable to add to them if not necessary.[12]

"The spirit of Temperance hovering over the fountain of pure water, looks mournfully upon him as though she would gladly restore him to happiness with the cup of life she holds" (From American Agriculturist *19:248[1860]).*



Dr. Fitch's home, Fitch's Point, Salem, New York (New York State Museum file photograph, dated September 19, 1900).

The farm consisted of some 600 acres, of which about 400 were as fine as any in the area. It was to be divided between Dr. Fitch and his brother, according to their father's will of about 1835.[13] In many ways it was typical of farms before the advent of specialized agriculture. Much of the production went directly into family consumption, with the surplus sold for profit. A hired hand or tenant with whom the profits were shared was frequently employed. In 1866, Dr. Fitch reported that the farm products – pork, butter, potatoes, flax, and flax seed – brought in over $1000, about the best ever. He attributed the success to his hired hand, Jim Mack.[14] Dr. Fitch spent much time tending the farm and watching over the help, with which he was frequently displeased. David Palen, his assistant in the winter of 1842, was an indifferent hand. He apparently complained about everything – tools the worst he ever used, work the hardest he ever did, cows the most unruly he ever milked, and so on. He was slow, not stout enough for hard work, hated getting his feet wet, did not work in the evening, ate like a glutton, never went to bed until late, and hated to get up in the morning. Only necessity compelled Dr. Fitch to employ Palen as long as he did.[15]

Despite a heavy schedule of farm business, Dr. Fitch found time to take leading roles in local educational pursuits, lecturing on botany at the Greenville and Salem Academies in 1840.[16] In 1842, at teachers' conventions in North Granville and Union Village, the doctor justified the introduction of natural history studies into the common schools.[17] In January of 1843 he travelled through severe weather from Salem to Cambridge to deliver an entomological lecture to a local lyceum.[18] Later that year an appointment to Salem's new office of Town Superintendent of Schools, unwelcome because of an already crowded schedule, was accepted, and he endeavored to discharge the duties faithfully. Grammar had always been his dislike in school, so Dr. Fitch purchased a textbook with the idea of reviewing the subject thoroughly.[19]

Although Dr. Fitch instructed some medical students after returning to Salem, he soon gave up formal practice.[20] He regarded himself as too honest to compete with the quacks and charlatans in the profession because of his resolve to give medicine only when needed and only in doses needed.[21] In 1847, he donated his saddle bags and remaining medicines to Robert H. Mack, who had decided to practice medicine at Crown Point.[22]

Dr. Fitch, like many early naturalists, had to constantly struggle to justify the study of natural history. At the 1842 teachers' conventions he argued that natural history combined exercise with instruction, provided entertainment throughout life, and was a constant source of interesting conversation.[23] Dr. Fitch also embraced reasoning derived from natural theology. Victorian naturalists had a difficult time justifying their pursuit in economic terms, but moral and religious justifications allowed it to become popular early in the nineteenth century. Natural theology provided the rational and respectable reason, as well as the excuse, for studying nature. It enabled a human being to approach a closer knowledge of God while engaged in a rational amusement. Dr. Fitch told the teachers' conventions that natural history gives insights into the character and perfections of the Deity — that it is one of the best safeguards against irreligion. Natural theology taught that plants and animals possess many structures and contrivances allowing them to survive and propagate the species, and that elaborateness, so obviously designed, was irrefutable proof that there must be a Creator. According to Dr. Fitch, we study nature because it teaches us that God exists, and because in it we can see His beauty and perfection.[24]

Similarly, Dr. Fitch explained to his friend George F. Horton why he was not an active abolitionist, although he did not favor slavery. He said the chief end of his existence was to glorify God and do good for his fellow creatures; that each individual must determine how he can best serve the purpose of Providence in placing him in this world:

> I need not conceal my purpose from you — perhaps you anticipate it already. It is, to show to my fellow men what God is as revealed in his works, even in a minute & little regarded section of his works. Minute though they be, yet in clear & incontrovertible terms do they declare many of the attributes of their maker; & lead to ideas of him, so exalted, so sublime, infinitely beyond what the uninformed can conceive of. Mark the harmony that pervades all the works of nature — does it not prove that there is *one* God? who created all. Mark the immense number of species, their endless variety of form, of color, of sculpture, of habits, — does it not declare the creator infinite — conceiving & planning, beyond the utmost stretch of ingenuity of all human intellect. Mark the evident pleasures & enjoyments given to every animated object, does it not bespeak the benevolence of the Deity — & his wisdom, & his power, in short all his natural attributes are here written in language which none can gainsay — 'tis evidence that there is a God — & that God the same of whom the Bible speaks which methinks none can resist. Be it my endeavor then to add my mite [might?] to that mass of evidence that declares the truth of the Scriptures — & show to my fellow men something more of the greatness & glory of that God in whom they live & move & have their being.[25]

With a distinct sense of religious purpose, Dr. Fitch proceeded with his scientific interests, not settling on one subject initially but jumping from botany to zoology to geology. After a season of studying botany, he reflected upon his unsettled state and described himself as like a tree set on fire by lightning; eventually the paroxysm would subside, or some other monomania would replace it. He wished to burn with one thing at all times in order to accomplish something worthwhile. "But I am unstable as water. . . . Just like a jackass, turning up whatever road fancy's rein seems to draw. 'Now what a thing it is to be an ass,' as Shakespeare says."[26]

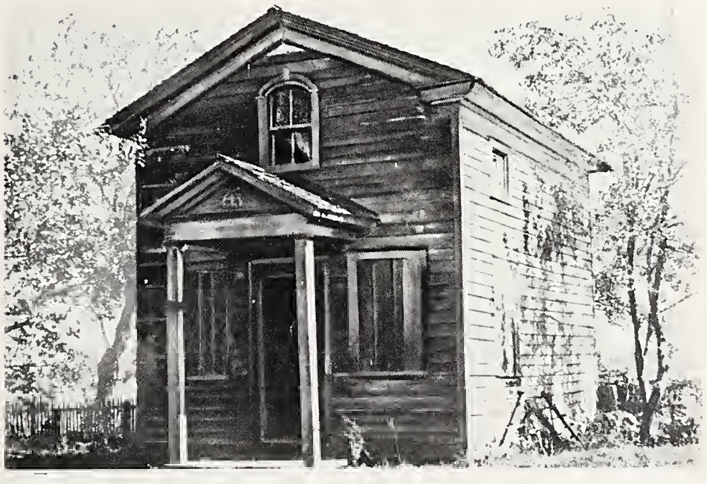
Dr. Fitch's attention was turned to geology and literature while wandering in the foothills of the Adirondack Mountains. The view so inspired him with a poetic frenzy that at one point we see him wishing in his diary that he could settle on the spot and compose an epic poem describing the dramatic events that the globe underwent from the time of Creation to the advent of man.

> What a grand theme! But who among the living or the dead is adequate to such a gigantic work. Not Homer, or Milton, or Pollock, could do full justice to it — & meetly tell of the rending of the rocks, the upheaving of the mountains, the terrific gaping clefts & fissures reaching the earth's centre, the floods bursting from sundered caverns; & all the inconceivably apalling [*sic*] spectacles that must have occurred, when this vast globe as if goaded by a thousand earthquakes was every where groaning & convulsed, & grinding with the pangs & throes & intensest agonies of a woman in travail.[27]

Despite varied interests, Dr. Fitch concentrated on insects. His collection included well over 6000 specimens before he returned to Fitch's Point.[28] In Salem, his neighbors nicknamed him "The Bug-Catcher." It has been said that he was frequently seen after a shower, on his hands and knees, searching for all kinds of creeping things, and he would eventually return home with his tall hat completely covered inside and out with "the writhing victims of his scientific greed." He was such a zealous collector that many thought him demented; others complained that he destroyed more grain than his scientific investigations were worth. Even when engaged in family worship some felt it was not safe for an insect to attract his attention. One time, a peculiar moth alighted upon the Bible as he was about to begin reading. Glancing around, as if conscious of some impropriety, he picked up his net, caught the unusual specimen, and with a half-guilty look proceeded with the reading. The moth proved to be new to science.[29]

As early as 1840, Dr. Fitch laid down a well-defined plan for his life's work:

> I have undertaken a very great work, and have laid upon myself a task both hard in the plan and difficult in the execution. To unite in one very limited body the most essential facts of the history of insects; to class them with precision and accuracy in a natural series; to delineate the chief traits in their physiognomy; to trace in a laconic and strict manner their distinctive characters, and follow a course which shall correspond with the progress of the science and the eminent men who have contributed to its advancement; to single out the useful and obnoxious species, those which from their manner of living interest our curiosity; to mark the thousand sources where the knowledge of the original authors may be consulted; to render to Entomology that amiable simplicity which she has had in the times of Linnaeus, of Geoffrey [Geoffroy?], and of the first productions of Fabricius, and yet present her as she is to-day, with all the richness which she has acquired from observation, but without surcharging her with it; to conform her, in one word, to the model which I have under my eyes, the work of Cuvier – such is the end which I have taken upon myself to attain."[30]



Dr. Fitch's office, sometimes known as the "bug house" (New York State Museum file photograph).

Historic marker indicating location of Dr. Fitch's home and office, Fitch's Point, Salem, New York.

For his natural history cabinets, Dr. Fitch outfitted the small medical office, a solid, well finished, frame building that Dr. Freeman had erected at Fitch's Point about 1822. Dr. Fitch had to get 20 yoke of oxen to move it nearer the house.[31] He installed a chimney and cleaned, secured, and whitewashed the building. In the back room shelves on three sides held minerals, of which Dr. Fitch had over 3000 specimens, vials containing animals preserved in spirits, and the papers containing his dried specimens of plants. The fourth side of the room was occupied by glazed cases for birds and insects. The office was his pride and joy.[32] During the first few winters back in Salem, Dr. Fitch had moved into the old barroom of the house. Later he occupied a back room, which was more convenient for his comfort and enjoyment, with desk and bookcase at hand. The window afforded a view of the farm and allowed him to inspect the hired help. His wife Elizabeth, however, disliked the change of rooms because of the cramped quarters and the clutter of natural history specimens.[33]

Elizabeth had been brought up by Puritan grandparents. Her mother, who had eloped with an Irish officer, died after Elizabeth was born, and her father returned to Ireland. The outraged grandparents discouraged any tendency toward Irish wit and gaiety. Consequently, the household at Fitch's Point retained many Puritan ways, including family prayers, grace before meals, and strictly observed Sundays. As Dr. Fitch's absorbing interest in the natural sciences intensified, his delicate wife became a strict disciplinarian and a characteristically neat and economical New England housekeeper. She did not like having her orderly house cluttered with specimens, and he was not happy with the dark rooms and excessive cleanliness. Elizabeth eventually learned that such neatness was not compatible with a growing family and many scientific guests.[34] Abby Martin was born in 1840, Anna Olivia in 1844, Elias Pattison in 1847, and Asa James in 1852.[35] During the Civil War, the eldest daughter, Sarah, moved back to Fitch's Point from Mississippi with her two children and three stepchildren.[36] The conditions soon crowded Dr. Fitch from his home, and he began sleeping on a settee in the office.

In the office, the mice sometimes made so much noise – rattling among papers, jingling vials, and jumping on the floor – that they kept Dr. Fitch awake until he improvised traps.[37] The settee often became so infested with voracious bedbugs that he was unable and unwilling to sleep upon it. His solution was to place the settee in the corn crib until all the creatures were starved out, or to treat their lurking places with a quarter ounce of corrosive sublimate.[38] He worried that the poison absorbed through his skin caused constant cracks in the corners of his mouth.[39] The office became cluttered with piles of newspapers, shreds of writing paper, unused labels, fallen pins, and other rubbish as Dr. Fitch worked assiduously on his scientific research.[40]

As a student, Dr. Fitch had experimented with the number of hours of sleep needed to maintain a healthy body and mind. Five hours nightly proved sufficient, and he constantly sat up until midnight or later and arose at daylight.[41] Lights in the "bug house" were frequently seen by passers-by. One evening in 1866, Dr. Fitch overheard some men riding by remark, "There's always a light there" – alluding to his office, and he supposed there was no other window along the road in which the travelers saw a light so constantly and so late at night.[42]

Conscious of his vulnerability alone in the office in the still, dark night, Dr. Fitch began to fear attack by a "desperado." He even had occasional dreams of being assaulted. In 1868, he purchased a revolver – "a pocket 'seven shooter' – silver mounted – made by Smith & Wesson . . ." – that he kept under his pillow.[43]

REFERENCE NOTES

[1] Asa Fitch Diary, 21 May, 28 June 1831, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University (hereafter records from the Fitch Diary are cited as Diary, followed by the date of the record).

[2] *Ibid.*, 12 May 1831.

[3] *Ibid.*, 14 June 1831.

[4] *Ibid.*, 13 Nov. 1831.

[5] *Ibid.*, 17 Jan. 1832.

[6] C. Johnson, History of Washington Co., New York (Philadelphia: Everts and Ensign, 1878), p. 186 (hereafter cited as Johnson, *History*).

[7] A. Fitch, "*The Spirit of the times. A Lecture* delivered before the *Salem Lyceum*, August 10, 1831, Stillwater Lyceum, January 31*st* 1837," p. 1, Manuscript Group 755 (Asa Fitch Collection), Department of Manuscripts and University Archives, Cornell University Libraries.

[8] *Ibid.*, pp. 9-10.

[9] A. Fitch, "Address delivered before the Stillwater Temperance Society at its monthly meeting, March 7th 1833," Manuscript Group 2086 (Asa Fitch Collection), Department of Manuscripts and University Archives, Cornell University Libraries; A. Fitch, Address [on temperance, undated], Museum of Science, Boston.

[10] A. Fitch, "The Jolly Club. No. 1. Introductory," undated manuscript, Manuscript Group 2086 (Asa Fitch Collection), Department of Manuscripts and University Archives, Cornell University Libraries. Another manuscript, "No. 3. The wise men of Gotham," exists in the same depository.

[11] A. Fitch, undated photostat copy of some Fitch manuscript genealogy notes, New York State Library.

[12] A. Cormier, Return to Fitch's Point, *The Journal Press*: *The Greenwich Journal*, *The Salem Press* 1984 (Mar. 8): 7.

[13] Diary, 24 Aug. 1840 (letter to Horton).

[14] *Ibid.*, 20 Jan. 1866.

[15] *Ibid.* (Memorandum book of farm), 1 Nov. 1842.

[16] *Ibid.*, 26 Mar. 1840 (letter to Robertson).

[17] A. Fitch, "Report on introducing the study of Natural History into Common Schools. Read at the Teachers' Convention at North Granville, Sept. 27, 1842. Teachers Convention Union village Oct. 25 1842," New York State Museum (hereafter cited as Fitch, Report).

[18] Diary, 3 Jan. 1843.

[19] *Ibid.*, 1-3 June 1843.

[20] *Ibid.*, 26 Mar. 1840; Johnson, *History*, p. 186.

[21] Diary (Memorandum book of farm), 17 Feb. 1842.

[22] Diary, 9 Aug. 1847.

[23] Fitch, Report, pp. 2-14.

[24] *Ibid.*, p. 11. The fullest and most influential exposition of natural theology was William Paley's *Natural Theology*: *or, Evidence of the Existence and Attributes of the Deity, Collected from the Appearances of Nature* (Philadelphia: John Morgan, 1802). In the United States, it was one of the most widely used college texts, and as late as 1885, Thomas Gallaudet's children's adaptation of Paley, *The Youth's Book on Natural Theology* (New York: American Tract Society, 1832) was still popular.

[25] Diary, 18 Feb. 1840 (letter to Horton).

[26] *Ibid.*, 24 Aug. 1840 (letter to Horton).

[27] *Ibid.*, 20 Sept. 1839.

[28] Dr. Fitch labelled nearly all of his specimens with individual numbers. He recorded these numbers consecutively in four individual registers, along with collecting dates, localities, and other pertinent information. Label numbers in black ink written on white paper are recorded in one register of specimens from New York State. Label numbers in black ink crossed with one or two red lines and written on white paper are recorded in a second register of specimens from New York State. One red line indicates a number less than 10,000, and two red lines indicate a number to which 10,000 should be added. Label numbers in red ink written on white paper are recorded in a third register that lists specimens from elsewhere in North America. These three registers are in the possession of the New York State Museum. The fourth register, owned by the Museum of Science, successor to the Boston Society of Natural History, lists specimens from elsewhere in the world. The corresponding labels are written in black ink on colored papers.

[29] E. P. Thurston, Sketch of Dr. Asa Fitch, *Pop. Sci. Monthly* 16(1879): 116-120.

[30] *Ibid.*

[31] Diary, 30 July 1847.

[32] *Ibid.*, 5 Dec. 1839 (letter to Robertson).

[33] *Ibid.* (Memorandum book of farm), 1 Nov. 1842.

[34] May Agnes Marston, "The Lady of the Diary *or* The Little Yankee Goes South," undated manuscript, Manuscript Group 2086 (Asa Fitch Collection), Department of Manuscripts and University Archives, Cornell University Libraries.

[35] A. Fitch, undated photostat copy of some Fitch manuscript genealogy notes, New York State Library.

[36] Diary, 25 Dec. 1865.

[37] *Ibid.*, 18 Aug. 1865.

[38] *Ibid.*, 9 July 1866, 15 June 1869.

[39] *Ibid.*, 23 June 1870.

[40] *Ibid.*, 5 Aug. 1871.

[41] D. L. Collins, The "bug catcher" of Salem, *Univ. State* N. Y. *Bull. to Schools* 40(1954): 193-196.

[42] Diary, 3 Feb. 1866.

[43] *Ibid.*, 3 Feb. 1868.

CHAPTER EIGHT

More Scientific and Agricultural Developments in New York State

While Dr. Fitch was becoming ensconced in the rural life and building a family in Salem, the movement for government-sponsored internal improvements was swelling in Albany. Political philosophers believed social and material leadership would bless the new nation if the sciences, especially the natural sciences, were applied to the common purposes of life. Although Europeans led in descriptive natural science, national pride dictated that Americans study America's natural productions. As the nation grew, agriculture expanded rapidly and scientific principles were applied to its improvement. After the invention of the steam-powered printing press in 1811, a new and thriving agricultural press brought new developments to the attention of a wide readership. The tradition of scientific amateurism gave way as the public, especially through the auspices of scientific and agricultural societies, lobbied for governmental support of scientific and agricultural surveys.

Governor Clinton repeatedly asked the New York State Legislature to encourage mineralogical research, particularly with a view to discovering coal. In 1813, Theodoric Romeyn Beck, in the annual address before Albany's Society for the Promotion of Useful Arts, had indicated that much unnecessary expense had been incurred in the search for coal because of the miners' ignorance.[1] During the 1829 legislative session, the Lyceum of Natural History of the City of New York presented a petition to the Legislature requesting an inquiry into the expediency of searching for coal in the State.[2] In 1834, the Albany Institute, under the presidency of Stephen Van Rensselaer, petitioned the Legislature for financial assistance to form a "grand and comprehensive collection of the natural productions of the State of New York, to exhibit at one view and under one roof its animal, vegetable, and mineral wealth." The Institute felt that valuable sources of wealth might be discovered. Furthermore, the Institute indicated that such collections are an object of national pride in every civilized country in Europe and that, as the French naturalist Cuvier pointed out, "Natural History is one of those sciences, in which genius is impotent, unless seconded by power, and the efforts of power vain, unless its results are arranged by the co-operation of genius."[3]

On April 18, 1835, a select committee reported to the State Assembly on a memorial from the American Institute of the City of New York, through which a natural history survey of the State was requested. The memorialists felt such a survey was too onerous to be undertaken by individual enterprise and too expensive to be reasonably expected from private scientific institutions.[4] That same day, the Assembly resolved to request the Secretary of State, General John A. Dix, to report on the most expedient method of obtaining a complete geological survey of the State, "which shall furnish a scientific and perfect account of its rocks, soils and minerals, and of their localities, a list of all its mineralogical, botanical and zoological productions, and provide for procuring and preserving the same. . ."[5]

Many years later, General Dix's son recalled the effects the extensive legislative instructions had on the Dix household. The General, delighted with the character of the work, began at once to collect information on natural history.

> The house was soon flooded with books on geology; Lyell, Mantell, and other authors appeared, and we children used to wonder at the plates representing incomprehensible monsters (the Plesiosaurus, the Megatherium, the Pterodactyl, and heaven knows what other shapes), which far more awful than any in the "Arabian Nights," confronted us as we peeped into those mysterious volumes. The General became an enthusiastic student of these works, and enlisted the family for the

> same pursuit. He entered into correspondence with the persons then looked up to as authorities in physical science; he was knee-deep in rocks and minerals, organic remains and alluvial detritus, and the treasure of the animal and floral kingdoms.[6]

The thorough and impressive report resulting from General Dix's work effectively pointed out the practical and scientific objectives of a State geological and natural history survey, and indicated that practical utility is the principal motive to support one. Concerning entomology, General Dix pointed out that Dr. Harris' contribution to the natural history survey of Massachusetts was merely a list of insects found in the State, and that the New York State Assembly's 1835 resolution only required a complete list with a full series of specimens.[7] "Yet in connection with such an account of the entomology of this State, as a part of its natural history, certainly no considerations are of greater importance than those which relate to economical purposes." He pointed out that the destructiveness of insects to vegetation was rarely considered, but that many of their devastations could undoubtedly be guarded against by a better knowledge of their habits.[8]

John Adams Dix (From M. Dix, Memoirs of John Adams Dix *[1883]).*

The General's report influenced the State Legislature to appropriate $104,000 for a four-year Geological and Natural History Survey. The governor was directed to employ a suitable number of scientists to make an accurate and complete geological survey of the State. Without hesitation, Governor Marcy signed the bill into law on April 15, 1836.[9] Funding was later extended for two more years.

Governor Marcy considered the magnitude and importance of the work. On the advice of Amos Eaton and Edward Hitchcock, a respected New England geologist, New York State was divided into four geological districts. Scientific appointments were made after consultation with a group of advisors that included General Dix, Stephen Van Rensselaer, Dr. T. R. Beck, Professor Eaton, and Edwin Croswell.[10] Army engineer William Williams Mather, Rensselaer School Junior Professor Ebenezer Emmons, conchologist Timothy Abbott Conrad, and Paris-trained geologist Lardner Vanuxem were appointed principal geologists. Dr. Lewis C. Beck was appointed mineralogist; Dr. John Torrey of New York, botanist; and Dr. James Ellsworth DeKay of Long Island, zoologist. After the first year of field work, Conrad was appointed the survey's paleontologist, and Mr. James Hall, a Rensselaer School graduate who had been Emmons' field assistant, was placed in charge of Conrad's geological district. Hall chose his Rensselaer School classmates George Boyd, Ezra Carr, and Eben Horsford as his field assistants.

Thus a scientific community developed in the capital district of New York State. Earlier in the nineteenth century, DeWitt Clinton had combined elements of the practical and the theoretical, the political and the scientific, and he persuasively advocated public promotion of science. The natural history survey, which eventually resulted in the 30-volume series entitled "Natural History of New York," has been called "certainly the most sweeping collective effort of American science in the nineteenth century."[11] It earned the approval of politicians and scientists alike and catapulted many of the staff scientists into national and international fame.

With the development of the new scientific community came many other significant developments. The survey geologists met regularly to exchange ideas and coordinate their work. In the fall of 1838, they met at the home of Dr. Emmons in Albany and discussed means of consulting with geologists in other states. At a second meeting at Dr. Emmons' home the next fall, a formal meeting was called for Philadelphia in April of 1840. At that meeting the Association of American Geologists was organized. Eventually, naturalists also wished to join the association, and in 1847 the American Association for the Advancement of Science was formed as an outgrowth of the earlier organization.[12]

James Hall, who had been a member of the Association from the outset, was instrumental in bringing its 1851 summer meeting to Albany. Professor Louis Agassiz, who had arrived at Harvard from Europe in 1846 and had assumed considerable authority as the arbiter of American science, was then president of the organization. The meeting was an exciting occasion for the people of the Albany area, and the city proved a generous host. James Hall used the meeting to gain support for a proposed University of Albany, which had received legislative approval and had been granted a charter earlier that year. The University was envisioned as a project of national scale – an ideal institution of European character that would promote both literature and science. The effort to advance the project was continued for several years through public meetings, appeals for State support, and preliminary offerings of lecture courses. The ambitious plan called for a first-rate faculty, including James Dwight Dana, John P. Norton, Benjamin Peirce, and even Louis Agassiz.

Early in 1852, it was announced that the University was in operation with law and medical departments and that money was available for an observatory. The scientific department was ready to offer courses stressing practical application: agriculture, engineering, chemistry, mineralogy, metallurgy, mining, and astronomy. Pleas for aid and encouragement continued, but the legislative proposal failed, despite the existence of the University's charter. Only the schools of law and medicine, and the privately endowed Dudley Observatory, materialized. The observatory was ready for inauguration in 1856, when the American Association for the Advancement of Science, with James Hall as president, again met in Albany. The occasion corresponded with the dedication of the new State Geological and Agricultural Hall. The institutionalization of the American scientific community, aided by many of Amos Eaton's intellectual offspring, was making substantial progress, even though the major national university project proved premature.[13]

Meanwhile, there was renewed interest in State aid for the promotion of agriculture. The State Board of Agriculture had ceased to exist in 1826 by a limitation of the 1819 law that created it. Soon many of the county agricultural societies also failed. However, in 1832 a convention of delegates and other interested citizens from the various counties was invited to meet in the Assembly Chamber in Albany. The New York State Agricultural Society was formed, a constitution was adopted, and the Society began planning its work. Reports were prepared on plans for an agricultural school, an experimental farm, a weekly agricultural paper, and an agricultural fair. The Society was incorporated by legislative action in 1836, and members besieged the State Capitol each year, pointedly meeting in Albany while the Legislature was in session. In 1841, the lawmakers capitulated and granted a substantial appropriation for agricultural improvements. The policy of State aid for agricultural improvements was revived, and a sum of $8000 a year for five years was appropriated with $700 going to the State Society and the remainder to the county societies.[14]

In 1842, the governor essentially abolished the Geological and Natural History Survey. Five years of field work on foot and horseback had been completed; the Survey had yielded much unsuspected new information, which was summarized in the four final geological district reports. Dr. Beck finished his final report on the mineralogy of the State, and Torrey and DeKay finished their reports on the botany and zoology of New York, respectively. Conrad, however, had failed in his duties, and there was no final report describing the fossils, although a representative collection was at hand. Also, no provision had been made for a report on the agriculture of the State, although this had been designated a subject of major interest in General Dix's plan for the Survey. Only James Hall and Ebenezer Emmons remained available in Albany to complete the work. They competed to persuade the Legislature to allocate funds to collect, study, describe, and publish on New York's wealth of fossils. In 1843, the governor was authorized to continue the various departments of the survey to ensure its completion as outlined in Dix's plan. Hall was appointed paleontologist and Emmons agriculturist.

James Hall, 1843 (New York State Museum file photograph).

James Hall devoted himself unremittingly to the Survey. His attributes as an astute observer, keen scientist, and prolific writer, with his inflexibility of purpose and dynamic personality, made Albany a mecca for aspiring paleontologists. In 1857 he built, at his own expense, a brick building – an apprentice school – to which would-be paleontologists, artists, draughtsmen, and collectors migrated. European and American scientists made their way to Albany to meet Hall. Occasionally, however, the State reduced or suspended Hall's financial support. He advocated the establishment of a permanent natural history project and formulated an ideal and proper relationship between state and science: that scientists should be exempt from political manipulation and have every facility afforded for their progress. Eventually, his ideals were realized, and science became secure in governmental support.[15]

Ebenezer Emmons (From American Geologist *7:1[1891]).*

But Ebenezer Emmons was not endowed with the singleness of purpose that possessed Hall. Although an indefatigable geologist of considerable renown, his interests included medicine, agriculture, chemistry, and natural history. Unlike the determined and headstrong James Hall, he was nervous, sensitive and deeply religious. Hall, who never compromised high ideals in favor of a tranquil environment, was constantly surrounded by an atmosphere of anxiety.[16] Emmons and Hall were at odds nearly from the time they first met.

Nevertheless, Emmons attempted to make the most of his new position. From 1846 to 1855 he produced five quarto volumes on the agriculture of New York, treating such subjects as soils, climate, fruits, and insects. The position also allowed him to surreptitiously present to the public a full exposition of his ideas on the Taconic System, which led to one of the most bitter controversies in geological science. In his 1846 volume on the agriculture of New York, Dr. Emmons included a lengthy treatment of his novel notions on the Taconic System of rocks in eastern New York.[17] His friend Asa Fitch had discovered two new fossil trilobites in Washington County; they seemingly were more ancient than any known, thereby representing an earlier chapter in the history of life on earth.[18] From this evidence, Dr. Emmons inferred that the Taconic rocks were older than any known fossil-bearing rocks from New York. Conrad and Vanuxem agreed; Hall intensely disagreed. Supported by William Mather, James Dwight Dana, William B. Rogers, and Henry D. Rogers, Hall argued that the Taconic rocks were merely deformed equivalents of the rocks to the west. The Taconic controversy raged for years, eventually overshadowing Emmons' major contributions to geology.

The enmity between Emmons and Hall grew when, in autumn of 1849, Hall was made aware of a proof sheet of a geological chart in the office of the Superintendent of Public Instruction. The chart, which had been prepared by James T. Foster, a schoolteacher from nearby North Greenbush, failed to mention the New York formations. Moreover, Hall had never heard of the audacious fellow who prepared it. He sent the chart to Louis Agassiz, who, always sensitive to the dignity of American science, was equally outraged. Letters of condemnation from both men were printed in the Albany newspapers, and Foster attempted to sue the scientists for libel.

Meanwhile, Dr. Emmons endorsed a quickly revised edition that included his Taconic System, and the chart was copyrighted, printed, and shipped to New York to be marketed to the State's schools. However, Hall apparently boarded the same boat that was to carry the shipment, and the charts never reached their destination. Professor Agassiz's court case was called, after many delays, in March of 1851. A preponderance of scientific talent supported Hall and Agassiz, including William Mather, Sir Charles Lyell, James Dwight Dana, the Rogers brothers, Edward Hitchcock, Eben Horsford, and Joseph Henry; only Dr. Emmons went to Foster's aid. The trial lasted for several days and ended in a nonsuit. Hall's case was never called. Emmons' scientific reputation emerged battered. With most influential scientists against him, he was effectively excommunicated from the ranks of American science. He remained for a while in Albany to work on his agricultural reports, but soon moved to North Carolina, where he accepted a position as State Geologist.[19] Ironically, Emmons' interpretation of the Taconic System has proven to be accurate.

As its scientific and agricultural communities developed, Albany's publishing industry was becoming prominent. For much of the nineteenth century, New York's capital city was second only to Boston in the number of books produced. In 1828, the first steam-driven printing press in the

United States was installed in Albany.[20] Government documents, including the natural history reports and the State Agricultural Society's *Transactions*, were major sources of business for the Albany publishing industry, and as it developed, agricultural publications proliferated. Agriculture was the cornerstone of the American economy, and Albany was at the hub of American agriculture. Situated at the confluence of the Hudson and Mohawk Rivers, the city was a natural funnel for the flow of people moving westward and for western produce moving eastward. The funnel became enlarged with the completion of the Erie Canal in 1825 and the spread of the railroad network in the succeeding decades. It was only natural that Albany would become an agricultural center of growing importance.

After the invention of the steam-powered printing press, inexpensive and popular newspapers, magazines, and other vehicles for disseminating useful knowledge multiplied, particularly those dealing with agriculture. The popular literature became filled with prescriptive writing as didactic Victorian authors sought to elevate and instruct their audiences. The farm papers battled with old superstitions, like "moon farming" and the belief in the transmutation of wheat to chess, a common weed in grain. They helped break down the prevalent opposition to "book farming," fostered scientific farming, and exposed swindlers who preyed upon the rural communities.

The beginning of agricultural journalism is usually dated April 2, 1819, when the successful *American Farmer* was inaugurated in Baltimore. Two months later, the *Plough Boy* was initiated in Albany. In the following decades, agricultural journals sprang up all around the country. It has been estimated that in the antebellum period more than 400 such journals were initiated. Most of them were short-lived, but the successful ones had a profound effect on the direction of American agriculture. On the eve of the Civil War, the circulation of the farm press was estimated at more than a quarter of a million.[21]

Two of the most influential farm journals were the *Cultivator* and the *Country Gentleman*, published in Albany. In 1834 the New York State Agricultural Society authorized publication of the *Cultivator*. After the first year the journal was turned over to Jesse Buel as sole editor and conductor, and under his lead it attained a prominence equalled by few farm papers in any part of the world. In many respects, the *Cultivator* was ahead of its time in stressing scientific farming and encouraging agricultural education and governmental support for agricultural improvements. To this end, Buel enlisted the aid of more than 200 correspondents of varied backgrounds. After Buel's death in 1839, Luther Tucker purchased the *Cultivator* and united it with the *Genesee Farmer*. Tucker advocated the establishment of agricultural experiment stations and introduced new departments on subjects like horticulture, veterinary science, poultry science, and entomology. In 1853, realizing that rural life was diversifying beyond the scope of the *Cultivator*, he inaugurated a weekly entitled the *Country Gentleman*, which acquired a national and international flavor. The *Cultivator*, its price reduced, was henceforth composed of articles selected from the new journal. In 1866 the two papers merged.[22]

Another significant nineteenth century development in Albany was the establishment of a State Cabinet of Natural History. The early memorials to the Legislature from the New York Lyceum of Natural History, the Albany Institute, and the American Institute all indicated a desire for a comprehensive collection of the State's natural productions. In his report to the Legislature on the feasibility of a geological and natural history survey, Secretary of State Dix stated that a large room would be necessary for a cabinet in which to preserve specimens collected by survey scientists, and he recommended joining two committee rooms in the Capitol for this purpose.[23] The 1836 law creating the survey directed that specimens be deposited in the State Library, but it was quickly realized that the library would be insufficient.[24] In his first annual report of the first geological district, William Mather suggested erecting a building to accommodate the survey's collections. "A State Museum of Natural History, like the British Museum, the Jardin des Plantes, or others in Europe, would do honor to the State, and be an example worthy of imitation by others."[25] Unfortunately, his entreaty fell on deaf ears in the Legislature.

Late in 1839, DeKay, Vanuxem, Emmons, Mather, Conrad, Hall, and Beck addressed a memorial to Governor Seward, recommending use of rooms in the old State Hall as a museum. The Governor communicated their memorial to the Legislature early in 1840.[26] Later that year, the Legislature provided that the old State Hall be refitted for a State Museum in which to arrange and display specimens and other materials obtained by the survey scientists.[27] By 1843, the transfer of specimens from the committee rooms of the Capitol was complete.[28] That same year, also the year in which Dr. Emmons was appointed to make an agricultural survey of the State, the State Agricultural Society was granted quarters in the old State Hall, and it started a library and agricultural museum.[29] In 1845, the Regents of the University of the State of New York were directed to provide for the safekeeping of the cabinets of natural history and to hire a curator, and the State Agricultural Society was granted free use of the cabinets subject to the regulations of the Regents.[30]

In 1854, the Legislature authorized the repair and enlargement of the old State Hall for the better arrangement of the expanding State Cabinet of Natural History and the accommodation of the State Agricultural Society and its museum.[31] It was soon found that the building, built in 1797, was unsafe for any additions, so the Legislature authorized its destruction and the erection of a new State Geological and Agricultural Hall.[32] The new building was dedicated to the cause of science on August 27, 1856, the occasion corresponding with the Albany meeting of the American Association for the Advancement of Science. More than 5000 people were present, accommodated un-

State Geological and Agricultural Hall (From P.A. Chadbourne & W.B. Moore [eds.], The Public Service of the State of New York, *vol.III [1882]).*

der a tent in Academy Park. On the stage sat the governor and other prominent politicians, prominent American clergymen, scientists, and a host of other dignitaries. More than 25 flags bearing titles of fields of human endeavor that made great strides in America during the Victorian Era – from geology, zoology, botany, and agriculture, to the press, steam, commerce, and art – were suspended over the stage.

Professor Agassiz was introduced and received enthusiastically. He spoke of the occasion as one of great interest for men of science and reminded the audience that when European geologists came to America they at once asked for directions to Albany. Professor Hitchcock, renowned for his role in the pioneer geological survey of Massachusetts and as ex-President of Amherst College, then stated that this was the first occasion in which a state government in America had erected a natural history museum. He believed Albany was the best place in the country to build the first geological hall because Albany County was the district where the first agricultural and geological survey was undertaken on this side of the Atlantic, if not in the world.[33]

The new hall was dedicated to the cause of agriculture on February 11, 1857, at the annual meeting of the State Agricultural Society. This was an auspicious occasion for American agriculture. The Society and guests, including the governor and lieutenant governor, various State officers, the Senate, and the Assembly, were richly entertained in the upper rooms. The group later assembled in the Society's spacious lecture room to hear remarks from various political and agricultural leaders: Benjamin Pierce Johnson, an internationally renowned agriculturist, ex-President and incumbent Corresponding Secretary of the Society – and its leading spirit for many years; Samuel Cheever, President of the newly established New York State Agricultural College; T. C. Peters, the assemblyman who introduced the original bill asking for expanded and improved accommodations for the Society; William Kelly, a member of the Senate and ex-President of the Society; and Governor John A. King, also an ex-President of the Society.

Eloquent addresses extolled the virtues of farming, the prominence of New York State agriculture, and the international leadership that the State Agricultural Society had taken in its efforts to scientifically improve agricultural practices and spread the new practices through various educational media, including fairs, exhibitions, publications, lectures, and reports on Society-sponsored investigations into scientific agriculture. It was asserted that the State's and the Society's international reputations in agriculture were firmly established with the dedication of a new hall designed and built for the combined purposes of science and agriculture.[34]

Indeed, the State Agricultural Society, like the State Cabinet of Natural History, soon proved worthy of the new edifice. The Society continued for many years as a national and international leader in the encouragement of scientific agriculture, agricultural education, and state and federal aid to agricultural institutions. A pioneer in agricultural progress, it was the inspiration for many other organizations; it lived through and played a major role in shaping a far-reaching agricultural revolution.[35] The new hall provided commodious space for offices, lecture facilities, an impressive library of thousands of foreign and domestic volumes, and an unsurpassed agricultural museum containing farm and home implements, seeds, minerals, pest insects, and many other curiosities from home and abroad.

The State Cabinet of Natural History went through many changes mandated by the State Legislature. In 1865, the Legislature, recognizing the great credit that the work of the Geological and Natural History Survey conferred upon the State, passed a resolution asking the Regents of the University to report on the means needed to maintain the Cabinet as a complete museum of natural history. The Regents sought the advice of prominent scientific men, including Alexander Agassiz, James Dwight Dana, and James Hall. They recommended Hall's plan for regarding the Cabinet as a series of collections in natural history that were to be increased and elaborated. The result of his well-conceived plan was immediate. He was appointed Curator and authorized to carry out his plan, which was supported by increased appropriations. Hall was now official head of two State departments of science – both contributing to the same end but independent in responsibility.[36]

In 1870, the State Legislature passed an act in which the State Cabinet was reorganized as a museum of scientific and practical geology and general natural history, to be known as the New York State Museum of Natural History. Hall was appointed Director and given power to appoint assistants or curators with the concurrence of the Regents, and for the first time an annual appropriation was made for salaries and the augmentation and preservation of the collections.[37] The Museum has evolved in organization, operation, scope, and facilities, and today it is a general museum — the New York State Museum. It is a reminder of the great legacy of pioneering work in the natural sciences that was encouraged and sustained by an inimitable interaction between political philosophers and scientists.

The Geological and Agricultural Hall became a favorite attraction for visitors. One journalist described its popularity in the *New York Weekly Tribune* of May 19, 1860:

> These rooms, as they well may be, are now not only a resort for denizens of the city to while away a leisure hour in surveying the treasures they contain, but the traveler, as he passes by and through Albany, puts down "a visit to the Agricultural and Geological Rooms" as one of the indispensables of his jaunt. They have become the resort of thousands each year, not only of the State of New York, but of all States and of all countries whose citizens visit our shores. Not only the farmer calls to make inquiries in this repository of the treasures of his calling, and the mechanic to witness the progress of art, but here, too, is the storehouse where the student of every profession may gather wisdom and treasure up instruction.[38]

Reference Notes

[1] T. R. Beck, *Annual Address Delivered by Appointment, Before the Society for the Promotion of Useful Arts, at the Capitol, in the City of Albany, on the 3rd of February, 1813* (Albany, 1813), p. 27.

[2] New York State Assembly Document 374, 1835.

[3] New York State Assembly Document 15, 1834.

[4] New York State Assembly Document 374, 1835.

[5] New York State Assembly Document 9, 1836.

[6] M. Dix, *Memoirs of John Adams Dix*, vol. 1 (New York: Harper and Brothers, 1883), p. 142.

[7] T. W. Harris, Insects, in *Report on the Geology, Mineralogy, Botany and Zoology of Massachusetts*, E. Hitchcock, ed. (Amherst, 1833), pp. 566-595.

[8] New York State Assembly Document 9, 1836.

[9] Laws of New York, Chapter 142, 1836.

[10] J. Hall, "The Geological Survey," in *The Public Service of the State of New York*, vol. 2, P. A. Chadbourne and W. B. Moore, eds. (Boston: James R. Osgood and Company, 1882), pp. 367-376.

[11] S. Rezneck, The emergence of a scientific community in New York State a century ago, *New York History* 43(1962): 211-238 (hereafter cited as Rezneck, Emergence).

[12] W. Goldring, "Office of Paleontology," in A Summary of the accomplishments and functions of the New York State Museum during the past century, 1836-1936. C. C. Adams, ed., *New York State Museum Bulletin* 317 (1939): 69-118.

[13] Rezneck, Emergence.

[14] W. Bacon, History of the agricultural associations of New York from 1791 to 1862, *Trans. N. Y. State Agric. Soc.* 23 (1864): 143-168 (hereafter cited as Bacon, History).

[15] Rezneck, Emergence; D. W. Fisher, Laudable legacy – a synopsis of the titans of geology and paleontology in New York State, in *New York State Geological Association 50th Annual Meeting Guidebook*, D. F. Merriam, ed., (Syracuse: Syracuse Univ. Dept. of Geology, 1978), pp. 1-24 (hereafter cited as Fisher, Titans).

[16] Fisher, Titans.

[17] E. Emmons, *Agriculture of New York: Comprising an Account of the Classification, Composition and Distribution of the Soils and Rocks, and the Natural Waters of the Different Geological Formations; Together with a Condensed View of the Climate and Agricultural Productions of the State*, vol. 1, Natural History of New York (Albany, 1846), pp. 45-112.

[18] D. W. Fisher, Emmons, Hall, Mather, and Vanuxem – the four "horsemen" of the New York State Geological Survey (1836-1841). *Northeastern Geology* 3(1981): 29-46.

[19] J. M. Clarke, *James Hall of Albany, Geologist and Paleontologist, 1881-1898* (Albany: published by the author, 1923), pp. 204-216 (hereafter cited as Clarke, *James Hall*).

[20] J. J. McEneny, *Albany, Capital City on the Hudson* (Woodland Hills, CA: Windsor Publications, 1981), p. 88.

[21] A. L. Demaree, *The American Agricultural Press, 1819-1860* (New York: Columbia University Press, 1941), pp. 3-19.

[22] *Ibid.*, pp. 340-344, 352-355.

[23] New York State Assembly Document 9, 1836.

[24] Laws of New York, Chapter 142, 1836.

[25] New York State Assembly Document 161, 1837.

[26] J. Hall, State Museum of Natural History, in *The Public Service of the State of New York*, vol. 3, P. A. Chadbourne and W. B. Moore, eds., (Boston: James R. Osgood and Company, 1882), pp. 482-488 (hereafter cited as Hall, State Museum).

[27] Laws of New York, Chapter 245, 1840.

[28] Hall, State Museum.

[29] Bacon, History.

[30] Laws of New York, Chapter 179, 1845.

[31] Laws of New York, Chapter 283, 1854.

[32] Anonymous, New York Geological Hall, *Trans. N.Y. State Agric. Soc.* 14(1855): v-vi; Laws of New York, Chapter 539, 1855.

[33] Anonymous, Inauguration of the State Geological Hall, *Frank Leslies Illustrated Newspaper* 2(Sept. 6, 1856): 203.

[34] B. P. Johnson, S. Cheever, W. H. Bogart, T. C. Peters, W. Kelly, J. A. King, and H. Baldwin, Dedication of the State Agricultural Hall, *Trans. N.Y. State Agric. Soc.* 16(1857): 41-83.

[35] Anonymous, *The One-Hundredth Anniversary of the New York State Agricultural Society* (Albany: New York State Agricultural Society, 1932), 106 pp.

[36] Clarke, *James Hall*, pp. 381-385.

[37] Laws of New York, Chapter 557, 1870.

[38] Quoted in Bacon, History, p. 165.

CHAPTER NINE

Dr. Fitch's Early Professional Involvements With the Scientific and Agricultural Community

Dr. Fitch watched the development of the Albany-based scientific and agricultural community with interest. He applied to Governor Marcy for the zoology post on the newly created natural history survey, proposing to spend summers in the field and winters with the European collections.[1] The Governor, however, favored James DeKay, a Long Island physician and zoologist with European training. In 1839, Dr. Fitch wrote DeKay to arrange an entomological assignment, but DeKay never responded.[2] Instead, he engaged the services of T. W. Harris in surveying the insects.[3] DeKay eventually chose not to treat the insects, though they were specifically mentioned in General Dix's survey plan as a group requiring study, and DeKay himself emphasized pest control to justify public funding for the study of zoology.[4] The zoological field was so vast that he could not complete the survey in the period stipulated by law.[5] Also, his health failed in 1841, and he never fully recovered.[6]

James Ellsworth DeKay (From H.L. Fairchild, A History of the New York Academy of Sciences *[1887]).*

After Dr. Emmons was appointed State agriculturist in 1843, he immediately found an opportunity to fully expose his theory of the Taconic System in a volume on the agricultural geology of the State. However, he was soon impelled to write about fruits and vegetables, and finally to treat the insects. James Dwight Dana did not fail to make fun of the "Pomologist" after the Foster trial. Others wanted to do the insect survey. The talented entomologist Samuel S. Haldeman even asked for the curatorship of the State Cabinet and the respected John L. LeConte felt he should have a share in the work. However, Emmons proceeded with it.[7]

Apparently as a result of his newly found interest in agriculture, Dr. Emmons, in partnership with Alanson J. Prime, a physician who graduated from the Rensselaer School in 1829, initiated the *American Quarterly Journal of Agriculture and Science* in Albany. Its purpose was to "multiply the means of increasing the products of the earth." To this end, Emmons and Prime engaged contributors with scientific and practical expertise, pledging payment for their efforts.[8] Dr. Fitch, who Emmons knew from his days at the Rensselaer School, was to write a series of articles on injurious insects.

Wheat, the most important esculent in North America from the time Europeans first settled the land, was an important export item even in the seventeenth century. It was the chief crop in New York State from its settlement until the Erie Canal and railroads brought a cheaper and better product from Ohio and the western states; even then it continued to be an important crop. Because of competition with the West, New York wheat growers improved their cultivation methods. Soil exhaustion, diseases, and insect pests forced wheat cultivation, which in New York began on Long Island, up to the river flats of the Hudson, then to the Mohawk, and finally to the famous Genesee Valley, which for a generation held the title "Granary of the Country." Between 1830 and 1840 the wheat midge and Hessian fly became so destructive that wheat growing almost ceased in eastern New York. It would be 10 or 15 years before successful control methods would allow a revival of wheat culture in central and eastern New York.[9]

It is not surprising that Dr. Fitch wrote his first three entomological articles on the wheat midge, Hessian fly, and related insects. In his first article, "Insects of the Genus Cecidomyia, Including the Hessian and Wheat-fly," published in 1845 in the first volume of Emmons' *Journal*, he proposed to deal with a group of insects that "justly ranks first in importance in the consideration of the tillers of our soil." He thus set for himself a goal for the next three decades — to present information on the taxonomy, ecology, destructiveness, and control of injurious insects in such a way that it would be useful to common farmers as well as scientists.[10]

In his second article, "The Wheat-fly," Dr. Fitch reviewed the history of the pest problem. He had briefly visited the eminent entomologist and Harvard librarian Thaddeus William Harris to gather information on the pest.[11] At his isolated home in Salem, he had few contacts with men of science, except the geologists in Albany, and was forced to copy from books borrowed from those with similar interests. A problem similar or identical to the American wheat fly (wheat midge) had existed periodically in Europe since the last half of the eighteenth century. Dr. Fitch found that it had been widely noticed in the agricultural papers, particularly the *Cultivator* and the *New England Farmer*, and that the identity of the wheat fly was in question. Some regarded it as an "animalcule of the *Vibrio* genus, analogous to the 'eels' generated in vinegar and paste," whereas others pronounced it a weevil or considered it the Hessian fly. It apparently started its ravages in northern Vermont about 1828 or 1829 and then spread from there until wheat culture around Salem was generally abandoned by 1832.

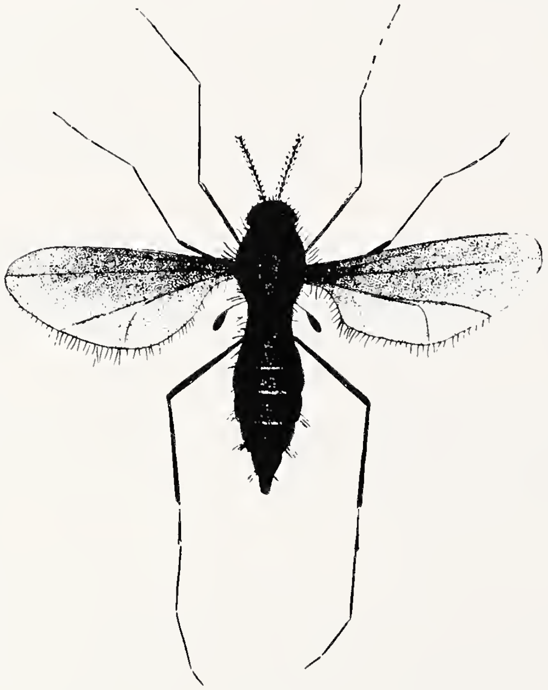


Illustration of the willow beaked-gall midge, Mayetiola rigidae *(Osten Sacken), from Dr. Fitch's first entomological article (Engraved by J.E. Gavit, from* American Quarterly Journal of Agriculture and Science *1:pl.2 [1845]).*

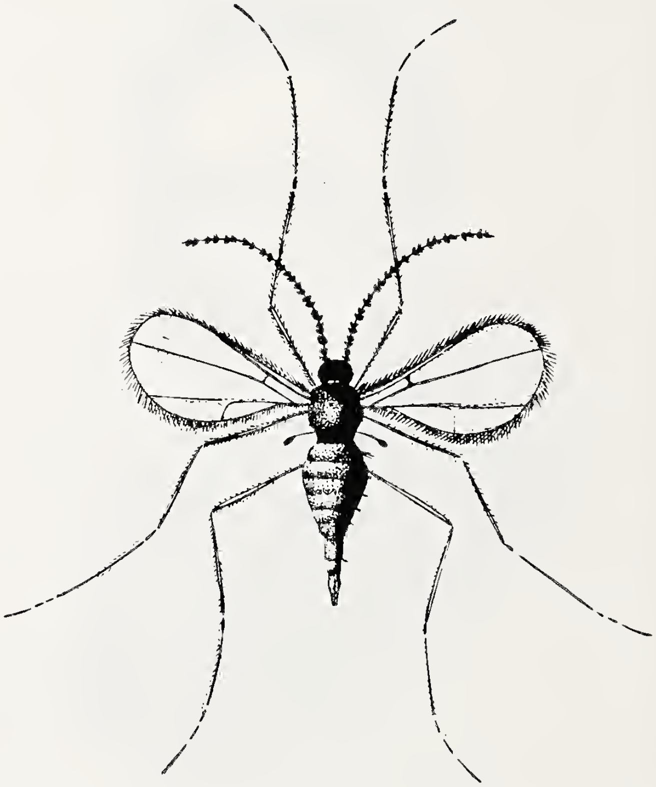


Illustration of a female wheat midge, Sitodiplosis mosellana *(Géhin), from Dr. Fitch's second entomological publication (Engraved by J.E. Gavit, from* American Quarterly Journal of Agriculture and Science *2:pl.5 [1845]).*

In the Genesee country, he noted, it was not detected until 1845.

Dr. Fitch then noted that the wheat fly problem went through somewhat regular cycles, lasting only one or two years before diminishing. He concluded that reduction of the fly's population was attributable to that "beautiful provision of nature. . . that an undue increase in any of the species of the animal or vegetable world never takes place, without being speedily succeeded by a corresponding increase of the natural enemies and destroyers of that species, whereby it again becomes reduced to its appropriate bounds." This reasoning led him to another important conclusion — that the entire life history and habits of the insect must be carefully investigated to enable the intelligent development of control measures. Dr. Fitch would develop this approach to pest problems to a high level in coming years. He would study many possible methods of control but always emphasize that a full knowledge of life histories provides the best hints for reducing pest populations.

Lantern in hand, Dr. Fitch visited infested fields at night and found myriads of flies "busily hovering about the grain. . . dancing, as it were, slowly up and down along the ears, intently engaged in selecting the most suitable spot where to deposit their eggs." The female "toils industriously to insinuate its ovipositor through the scale," deposits eggs, and then she is left with the laborious task of withdrawing her ovipositor. ". . . The energies of the insect are sometimes inadequate, and it remains, Prometheus-like, chained to an immovable mountain, until it expires."

Dr. Fitch traced the insect's life cycle from the egg to the larva, which feeds on developing grain, to the overwintering "dormant larva," to the spring pupa, and back to the adult. He then reviewed the known natural enemies of this tiny creature — birds and one species of parasitic wasp in America and four or more species of wasps abroad. Could these be manipulated to control the pest? Artificial control methods then in use seemed ineffectual, if not ludicrous. They fell into two categories — those that protect the grain from the fly and those that destroy the fly. The use of smoldering fires or brimstone to repel the insects was discouraging because of the amount of labor involved. Someone suggested suspending yarn impregnated with fluid from the scent glands of skunks in wheat fields to repel the flies. "I imagine that in carrying this suggestion into practice, the operator would be *the greatest sufferer* — 'unless *my nose* deceives me.' " Dr. Fitch persuaded a neighbor to experiment with slaked lime as a repellent, but heads of grain treated with it, when observed at night under lantern light, had as many flies hovering about them, ready to deposit eggs, as untreated heads.

Preventing the wheat from blossoming when the insect appears seemed more plausible to Dr. Fitch. In other words, sow winter wheat early and spring wheat late to shield the grain from the pest. Evidence seemed inconclusive, but this method worked and led to more successful wheat culture.[12] Dr. Fitch also suggested destroying the larvae after grain is threshed. The usual habit had been to throw the infested chaff out of the barn, thus unknowingly allowing the pest to live. "Now it is scarcely necessary for me to say, that the screenings of the fanning-mill should invariably be closely examined, and if the minute yellow wheat-worms are numerous in them, the person should consider it a sacred duty which he owes to himself and his neighbors, to consign these screenings at once to the flames."

Dr. Fitch ended his paper with a description of the wheat midge, which he concluded was identical with the European pest. The paper was published with some errors concerning the insect's metamorphosis because he was "under whip and spur" from his editor.[13] But this timely paper was unusually thorough and well illustrated — a masterpiece for its time.[14] Dr. Fitch had it reprinted in pamphlet form for distribution to scientists and agriculturists.[15] The State Agricultural Society also had it printed in its *Transactions* for 1845 and in pamphlet form.[16] It was widely noticed in foreign and domestic agricultural journals, including the *Gardeners' Chronicle* in England and the *American Agriculturist*, the *American Farmer*, and the *Ohio Cultivator*. Dr. Fitch quickly became known to the agricultural and scientific world for his careful observations and perspicuous style.[17]

The period 1846 to 1848 was important for Dr. Fitch's professional development. He produced a lengthy review of the Hessian fly problem for Dr. Emmons' *Journal*, and it, too, was reprinted by the State Agricultural Society, reissued in pamphlet form, and reviewed by the agricultural press.[18] His articles on winter insects of eastern New York and the currant spanworm were widely noticed in America and Europe.[19]

In 1846, Dr. Emmons requested Dr. Fitch's help in preparing his volume on the insects of New York for the natural history survey.[20] The volume, published in 1855, only contributed to Emmons' already tainted scientific reputation. The plates, which his son had drawn, were criticized for their poor execution and coloring, and the text was severely criticized for its many errors. Emmons' unprofessional treatment of the insects was decried by J. L. LeConte years later as a "striking illustration of waste of money" and a "permanent example of misplaced confidence and liberality; an equal disgrace to the legislation, the science and the art of the great state in which it was published."[21] Even before he had seen a copy, Dr. Fitch regretted having worked on the volume; he did not want his name associated with it. He explained to Dr. Harris early in 1855:

> I have not yet obtained Emmons' "big book." Indeed, I dread looking into it, knowing what a hotch-potch thing it must be, and not knowing what use has been made of my name in it. Last September, as I was packing up to start next day on a journey, the Dr. unexpectedly dropped in on me,

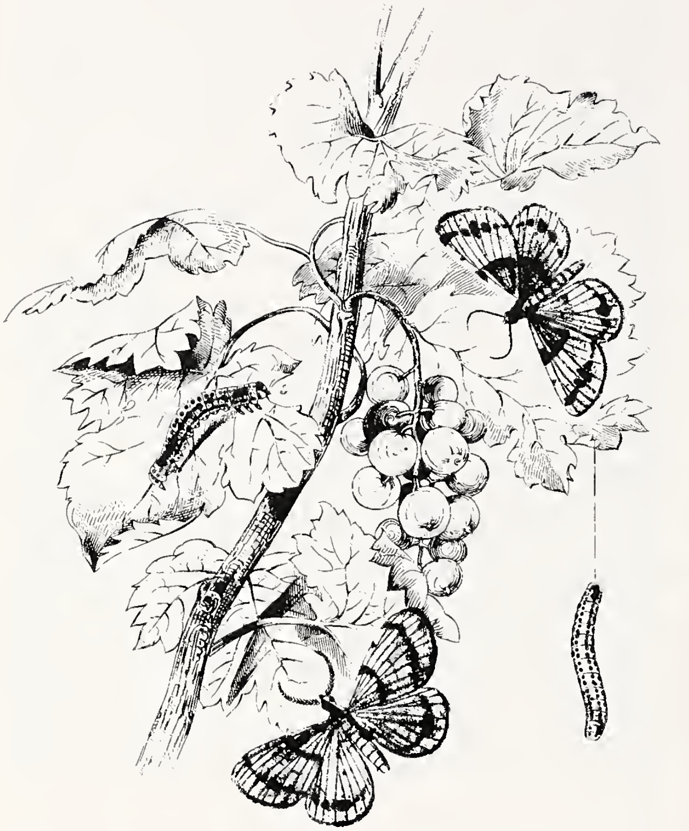
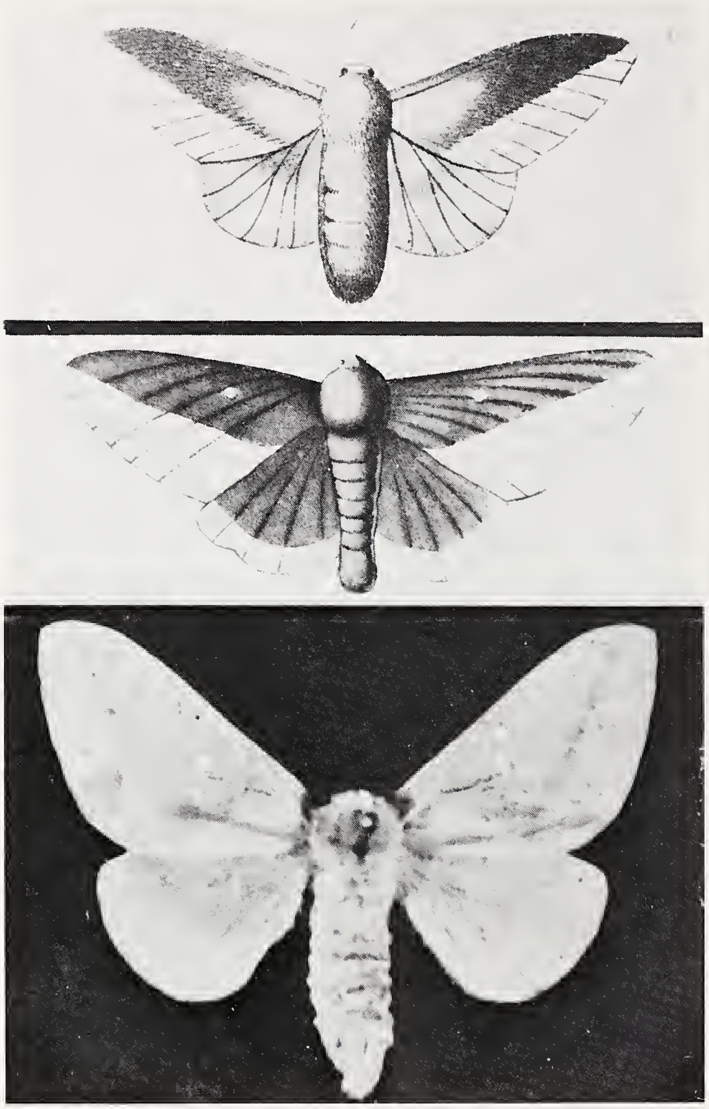


Illustration of the currant spanworm, Itame ribearia *(Fitch), from one of Dr. Fitch's early entomological publications (Engraved and printed by Gavit & Duthie, from* Transactions of the New York State Agricultural Society *7:460 [1848]).*

> with a bundle of the engravings, for me to *name the figures* therein. The specimens from which the drawings were made he did not think it was necessary to bring, as the figures were "perfectly accurate" *showing everything* which the specimens showed! On hastily glancing over the plates (for I had not time to examine deliberately) some of the figures I recognized, others I could only guess at, & others still I could form no conception of what they were. He also looked over my cabinet and took down some names from thence, although informed they were of no value, some of the families having been ticketed many years ago, when I had scarcely any authorities at hand to aid me in the work. As mineralogy is the Doctor's specialité, and I have some minerals which I should like to have named, I think it will be but fair for me to ask the Dr. to reciprocate the favor he asked of me, and send him "accurate drawings" of these minerals, that he may name them for me. Like his volume on Fruits, this on Insects, I think, must fall still born from the press.[22]



Illustrations of female pinkstriped oakworm moths, Anisota virginiensis *(Drury), from Emmons'* Insects of New York *(top and middle) compared with a photograph of a pinned, museum specimen (bottom) (Top and middle illustrations from pl.36, fig.1, and pl.40, fig.5, respectively).*

Emmons' report, entitled *Insects of New York,* contains little new or original material. The only new species described are 15 or 16 treehoppers (Membracidae), for which Dr. Fitch provided specimens and generic and specific names. In 1846, when Emmons requested his assistance, Dr. Fitch had been collecting and studying Orthoptera, Hemiptera, and Homoptera (including Membracidae). He found the Homoptera in unexpected numbers and decided to work up several new species for Emmons' book.[23]

Now that he was so engrossed in entomological work, Dr. Fitch decided to produce, as far as possible, a full manuscript catalog of all known species of insects, a seemingly prodigious task, but it was thought then that only about 30,000 species of insects occurred in the United States, with only about a tenth classified and described.[24] Dr. Fitch estimated that there were about 600,000 species worldwide, with only about a sixth described. "And here I would enquire, if any one will presume to say, that the hand of Omnipotence has exerted itself to populate the earth with such myriads of living, acting creatures for no purpose? Will any one dare to assert that these countless hosts were

'born to live unseen
'And waste their beauties on the desert air'?"[25]

Harris encouraged Dr. Fitch to work on the Homoptera and lent him books and papers to aid the new project. Overburdened with other cares, Harris was abandoning entomological work.[26] Dr. Fitch initiated the work but quickly found more avocations. After the State Legislature revived the policy of aid for the promotion of agriculture in 1841, a new Washington County Agricultural Society had been formed. Following the example of his father's involvement with the earlier county society, Dr. Fitch had become involved with the new society from the beginning. He had actively participated in its organization, served as its secretary, and, in 1848, served as its president.[27] The State Agricultural Society, always interested in new ways of improving agriculture, initiated a program of county agricultural surveys in 1847. Dr. Fitch was engaged to survey Washington County. Not only was he involved in his local society, but he had been trained by Amos Eaton, the man who had conducted the first agricultural and geological survey on this side of the Atlantic.

The State Agricultural Society's Executive Committee adopted an extensive plan for the county survey. B. P. Johnson, Corresponding Secretary, indicated that as the first survey attempted by the Society, and it was expected to be a model for the other counties. The 21 points of the plan called for a survey of the state of agriculture in the county and every subject connected with it – from minerals, fossils, soils, and insects, to the history of settlement, crop yields, sustaining industries, and the state of education.[28]

Dr. Fitch went to work with typical zealousness. In his geological work he was aided by Charles B. Adams, a Middlebury College professor of natural history who had cooperated with Professor Hitchcock and W. W. Mather in the New York and Vermont geological surveys. Professor Adams was Dr. Fitch's closest neighbor with similar tastes for natural history, and they quickly became friends.[29] In the historical work, Dr. Fitch found a subject that interested him more deeply than he supposed anything could except natural history.[30] To collect historical information, Dr. Fitch took the novel approach of visiting octogenarians in the county who had lived there in childhood. While gathering information on agricultural history, he found that many of the people he interviewed remembered details of the Revolutionary War, and he deemed it his "paramount duty to carefully rescue from oblivion and preserve to the world, such impressive mementos of those pangs which attend a nation's birth."[31]

Dr. Fitch's survey report was published in two sections in the *Transactions of the New York State Agricultural Society* for the years 1848 and 1849.[32] Although not the complete agricultural survey the State Agricultural Society intended, it was more thorough than any yet attempted in any district of the State and, indeed, a model to be followed. The historical portion of the report attracted much general notice and led to Dr. Fitch's election as a corresponding member of the New York Historical Society and an honorary member of the New Jersey Historical Society.[33] He continued to collect historical notes on Washington County for the rest of his life, amassing some 1800 pages.[34]

Having completed the survey of Washington County, Dr. Fitch returned to entomology and his research on the Homoptera. The Regents wanted an insect collection for the State Cabinet of Natural History. Apprised of the ardor and success with which Dr. Fitch had been pursuing entomology, they requested his aid, and he readily assented to their wishes, presenting about 600 specimens, mostly beetles, from his personal collection. In 1849, he published a catalog of this early, public collection.[35] He acknowledged the haste with which it had been assembled, and Samuel Haldeman was suspicious of the identifications.[36] The Regents, however, predicted that if Dr. Fitch were sustained in his pursuits, a fine public collection would be formed, affording the "best facilities for studying such as are noxious to vegetation and destructive to fruits." The State paid Dr. Fitch $80 for the specimens and their curation.[37]

By 1848, Dr. Fitch decided to revise the taxonomy of the New York representatives of the order Homoptera. He not only borrowed books from Dr. Harris to aid his investigations but also Harris' entire collection of Homoptera.[38] In return, Dr. Fitch added specimens from his personal collection to Dr. Harris' collection.[39] Early in 1851, Dr. Fitch published a catalog of about 300 specimens of Homoptera that he collected and arranged for the State Cabinet of Natural History.[40] In it, he described 6 new genera, 85 new species, and 5 new subspecies.[41] Dr. Fitch was paid another $80 for his services to the State.[42]

REFERENCE NOTES

[1] M. Aldrich, *New York Natural History Survey, 1836-1845*, Ph. D. Thesis, The University of Texas at Austin, 1974, pp. 94-95 (hereafter cited as Aldrich, *Survey*).

[2] Asa Fitch Diary, 26 Mar. 1840 (letter to Robertson), Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University.

[3] New York State Assembly Document 50, 1840.

[4] Aldrich, *Survey*, p. 131.

[5] New York State Assembly Document 137, 1855.

[6] Aldrich, *Survey*, pp. 208, 336.

[7] J. J. Clarke, James Hall of Albany, Geologist and Palaeontologist, 1811-1898 (Albany: published by the author, 1923), p. 238.

[8] E. Emmons and A. J. Prime, To the public, *Amer. Q. J. Agric & Sci.* 1(1845): 1-7.

[9] U. P. Hedrick, A History of Agriculture in The State of New York (New York State Agricultural Society, 1933), pp. 331-332 (hereafter cited as Hedrick, *History*).

[10] A. Fitch, Insects Injurious to Vegetation. No. 2. Insects of the Genus *Cecidomyia*, including the Hessian and Wheat-fly, *Amer. Q. J. Agric. & Sci.* 1(1845): 255-269.

[11] A. Fitch to T. W. Harris, letter dated 30 Dec. 1846, file bMu. 998. 10. 2, Museum of Comparative Zoology, Harvard University.

[12] Hedrick, *History*, p. 335.

[13] A. Fitch to T. W. Harris, letter dated 12 Jan. 1847, file bMu 998. 10. 2, Museum of Comparative Zoology, Harvard University.

[14] A. Fitch, Insects injurious to vegetation. - No. 3. The Wheat fly. *Amer. Q. J. Agric. & Sci.* 2(1845): 233-264.

[15] A. Fitch, *An Essay Upon the Wheat-fly, and Some Species Allied to it* (Albany: published by the author, 1845), 32 pp.

[16] A. Fitch, The Wheat-fly, *Trans. N. Y. State Agric. Soc.* 5(1846): 255-291; A. Fitch, *An Essay Upon the Wheat-fly, and Some Species Allied to it* (Albany: New York State Agricultural Society, 1846), 38 pp.

[17] J. O. Westwood, Entomology. The Wheat midge, *Gardener's Chronicle* 37(1847): 604; Anon., The Wheat fly, *Amer. Farmer* 1, ser. 4 (1846): 243-245; Anon., An essay upon the wheat midge, and some species allied to it, *Amer. Agric.* 5(1846): 37.

[18] A. Fitch, Insects injurious to vegetation. - No. IV. The Hessian fly, *Amer. Q. J. Agric. & Sci.* 4(1846): 244-264, 257*-264*; A. Fitch, Insects injurious to vegetation. - No. V. The Hessian Fly. - (continued), *Amer. J. Agric. & Sci.* 5 (1847): 1-27; A. Fitch, *The Hessian Fly, Its History, Character, Transformations, and Habits* (Albany: published by the author, 1846), 63 pp.; A. Fitch, The Hessian fly: its history, character, transformations, and habits, *Trans. N. Y. State Agric. Soc.* 6(1846): 316-373; A. Fitch, *The Hessian Fly: Its History, Character, Transformations, and Habits* (Albany: New York State Agricultural Society, 1847), 60 pp.

[19] A. Fitch, Winter insects of eastern New York, *Amer. J. Agric. & Sci.* 5(1847): 274-284; A. Fitch, the currant-moth, *Abraxas? ribearia*, *Trans. N. Y. State Agric. Soc.* 7(1848): 461-469; A. Fitch, *The American Currant Moth, (Abraxas?ribearia)* (Albany: New York State Agricultural Society, 1848), 11 pp.

[20] E. Emmons, *Insects of New York*. Agriculture of New York, vol. 5. Natural History of New York (Albany, 1854[1855]), 272 pp.

[21] J. L. LeConte, Hints for the promotion of economic entomology in the United States, *Amer. Nat.* 7(1873): 710-722.

[22] A. Fitch to T. W. Harris, letter dated 26 Feb. 1855, file bMu 998. 10. 2, Museum of Comparative Zoology, Harvard University.

[23] A. Fitch to T. W. Harris, letter dated 30 Dec. 1846, file bMu 998. 10. 2, Museum of Comparative Zoology, Harvard University; J. K. Barnes, The Membracidae and other Homoptera described by Asa Fitch, 1851, and Ebenezer Emmons, 1855: Historical perspective and analysis, *J. N. Y. Entomol. Soc.* 9(1984): 27-34.

[24] *Ibid.*

[25] A. Fitch, untitled manuscript lecture on entomology, 1853, p. 17, New York State Museum.

[26] T. W. Harris to A. Fitch, letter dated 6 Jan. 1847, file bMu 1308. 10. 10; A. Fitch to T. W. Harris, letter dated [1848], file bMu 998. 10. 2; Museum of Comparative Zoology, Harvard University.

[27] C. Johnson, *History of Washington Co., New York* (Philadelphia: Everts & Ensign, 1878), pp. 163-166, 186 (hereafter cited as Johnson, *History*).

[28] B. P. Johnson to A. Fitch, letter dated 12 May 1847, published in *Trans. N. Y. State Agric. Soc.* 7(1848): 35-38.

[29] A. Fitch to T. W. Harris, letter dated 30 Dec. 1846, file bMu 998. 10. 2, Museum of Comparative Zoology, Harvard University.

[30] A. Fitch to T. W. Harris, letter dated 13 Nov. 1850, file bMu 998. 10. 2, Museum of Comparative Zoology, Harvard University.

[31] A. Fitch to the Executive Committee of the New York State Agricultural Society, letter dated 14 Jan. 1848, printed in *Trans. N. Y. State Agric. Soc.* 7(1848): 38-42.

[32] A. Fitch, A historical, topographical & agricultural survey of the County of Washington, *Trans. N. Y. State Agric. Soc.* 8(1849): 877-975; 9(1850): 753-944.

[33] Johnson, History, p. 186.

[34] The original manuscript notes, entitled "Notes for a History of Washington County," are in the possession of the New York Genealogical and Biographical Society, New York City. Extracts from the notes have been published in W. Adler, ed., *Their Own*

Voices (Interlaken, N. Y.: Heart of the Lakes Publishing, 1983), 158 pp.

[35] A. Fitch, Catalogue of the insects in the State Cabinet of Natural History, December 1, 1848, *Second Annual Report of the Regents of the University, on the Condition of the State Cabinet of Natural History, With Catalogues of the Same* (New York State Senate Document 20) 1849: 27-39.

[36] A. Fitch to S. S. Haldeman, letter dated 14 Nov. 1849, Academy of Natural Sciences of Philadelphia.

[37] Regents of the University of the State of New York, Report, *Second Annual Report of the Regents of the University, on the Condition of the State Cabinet of Natural History, With Catalogues of the Same* (New York State Senate Document 20) 1849: 9-14.

[38] A. Fitch to T. W. Harris, five letters dated 30 Dec. 1846, 22 June 1848, 13 Nov. 1850, 20 Feb. 1851, 1-4 Mar. 1851, file bMu 998. 10. 2, Museum of Comparative Zoology, Harvard University.

[39] The Harris Collection is at the Museum of Comparative Zoology, Harvard University. Many Fitch specimens in it have been recently recognized as valuable type specimens. See J. K. Barnes, Recently recognized types of some Homoptera described by Dr. Asa Fitch, *Psyche* 91(1984): 133-139.

[40] A. Fitch, Catalogue with references and descriptions of the insects collected and arranged for the State Cabinet of Natural History, *Fourth Annual Report of the Regents of the University, on the Condition of the State Cabinet of Natural History, and the Historical and Antiquarian Collection, Annexed Thereto* (New York State Senate Document 30) 1851: 46-69.

[41] The New York State Museum, lineal descendant of the State Cabinet, still possesses original specimens of 60 of the species and subspecies. See J. K. Barnes, The Membracidae and other Homoptera described by Asa Fitch, 1851, and Ebenezer Emmons, 1855: historical perspective and analysis, *J. N. Y. Entomol. Soc.* 92(1984): 27-34.

[42] Regents of the University of the State of New York, Report, *Fifth Annual Report of the Regents of the University, on the Condition of the State Cabinet of Natural History, and the Historical and Antiquarian Collection Annexed Thereto* (New York State Assembly Document 122) 1852: 9-14.

CHAPTER TEN

The State Supports Entomological Research

Only a few years before Dr. Fitch started his work on economic entomology, insects were seldom regarded as serious pests, although they were seen as obnoxious and sometimes dangerous. Man's agricultural practices recently (geologically speaking) had changed ancient, stable relationships between plants and insects, unwittingly producing pestilence. He arrived only after the plants and herbivorous insects had lived in equilibrium, with neither becoming threatened or multiplying excessively for some 200 million years. It is unlikely that man had much evolutionary influence on plant-insect relationships at the time of his appearance, but after he invented agriculture, about 10,000 years ago, he began to significantly alter these relationships to his own detriment.[1]

The evolutionary relationships between plants and insects were probably little influenced by the sparse populations of Indians in the northeastern United States, and even the advent of Europeans probably did not alter the relationships much. The crops of the early American colonists, which occupied a relatively small acreage, apparently did not suffer serious insect attacks. Few insect pests had been introduced from other countries, and apparently few native insects attacked the cultivated plants. The infrequent attempts at insect control were unorganized. In puritanical New England, insect infestations were believed to result from the sins of people. As late as the mid-eighteenth century, fasts were held to beg deliverance from the scourges of caterpillars.[2] In fact, prior to the nineteenth century, poor weather, soil exhaustion, and restrictive socio-economic conditions were the greatest deterrents to successful harvests; insect problems remained in the background.

As human population and the acreage and variety of crops increased, more and more demands were made on the environment. A new ecology was created in North America in only about two centuries. Plants and insects were thrust into this new world and forced to pursue their co-evolution. The ancient stabilized relationships were altered in an incredibly short time; the environment of native plants has been dislocated, and the ecology, physiology, genetics, and culture of domesticated plants have been so manipulated that they are incapable of reproducing without man's assistance. They no longer co-evolve with their environment and pests. These "modern" plants are more susceptible to pests and diseases.

Late in the the eighteenth century, farmers became concerned about insect damage to their crops. The idea of insects as pests was born, and the number of injurious insects seemed to increase with time. This advancement of insect pests reflects advances in colonization, agriculture, transportation, and commerce, and the continuing inter-

"American Farm scenes – Summer." American agriculture expanded rapidly in the nineteenth century. The expansion was accompanied by an unprecedented increase in the ravages of pest insects (Original sketch by F.O.C. Darley, from American Agriculturist *20:208 [1861]).*

ference with ancient plant-insect relationships. These practices set the stage for native insects, like the migratory grasshopper, armyworm, chinch bug, Colorado potato beetle, grape phylloxera, plum curculio, corn earworm, and others to multiply on an abundance of food and to follow the crops into new frontiers. The stage was set for the introduction of insects like the cotton boll weevil, Mexican bean weevil, codling moth, European corn borer, Hessian fly, Japanese beetle, alfalfa weevil, and many others to thrive in a new world. As the Agricultural Revolution progressed, old problems like bad weather, soil exhaustion, and restrictive socio-economic conditions receded into the background, and insect damage attracted increasing attention.[3]

America came to be viewed as "the land of insects," and Dr. Fitch pondered the alarming problem.

> And that America *is the land* of insects — that we are here sustaining greater losses from this class of objects than are experienced in corresponding parts of the old world — and that we shall be obliged to study their habits in order to successfully combat them and prevent their ravages, before our soil can possibly sustain so dense a population as exists *there*, scarcely admits of a doubt.[4]

Dr. Fitch had constant occasion to examine reports on the injurious insects of Europe. He concluded that the losses sustained in America immeasurably surpassed those in Europe. Insects regarded as serious evils there were deemed scarcely worthy of notice in this country because the damage they caused was so trivial. There, if an insect pest reduced the wheat crop by 10 percent, communities became alarmed, but here so slight a loss passed unnoticed. The same insects that appeared harmless or only occasionally attracted attention as pests in Europe appeared to become "armed with the club of Hercules" upon crossing the Atlantic. They seemed to advance over America like an invading army, devastating the vegetation in their path. They continued their depredations season after season, and not for many years did their destructiveness subside.

Noxious insects presented a philosophical problem for those who drew arguments from natural theology to explain how natural phenomena were designed to benefit man. Echoing Linnaeus, Dr. Fitch styled insects "the diligent and faithful servants of nature — perpetually engaged in destroying all that is dead, and checking the increase of all that is living in the vegetable world." [5] Man, he said, destroys the natural balance by making one plant occupy the land to the exclusion of all those others that nature decreed should diversify the same spot. "Nature, as it were, resents this violence done to her arrangements, and seeks to restore the equilibrium and preserve the harmony which her laws require." Dr. Harris observed that destructive insects are limited by the elements and natural enemies, including other insects, but "too often, by an unwise interference with the plan of Providence, we defeat the very measures contrived for our protection."[6] Victorians commonly refused to believe that Divine Providence had placed any insect enemy in this world without also endowing man with sufficient intelligence to discover a means by which to overpower it. "But all interference with the laws of the Creator is limited. Man is not allowed to extirpate, though he is permitted to reduce and restrain these pests within narrowed limits."[7]

"American Farm Scenes — Autumn." Victorian naturalists understood that man destroys the natural balance by making one plant occupy the land to the exclusion of all those others that Nature decreed should diversify the same spot (Original sketch by F.O.C. Darley, from American Agriculturist *20:336 [1861]).*

By the early 1850's, New York State's citizens and legislators were painfully aware of the desirability of studying the insect fauna. Agriculture was the cornerstone of the American economy — a fact reflected in society and politics. It controlled a larger amount of capital and a larger work force than any other industry and largely determined the direction of government policies.[8] American agriculture expanded westward with the growth of transportation facilities. By the 1840's, western farmers were competing successfully with New York and New England farmers for urban markets created by the Industrial Revolution and the expansion of specialized agriculture in the South. With the economy in a state of flux, New York and New England farmers worried about their worn-out soil and the diseases and insects that plagued their crops.[9]

As insect damage increased at an alarming rate, Americans realized something had to be done. The Massachusetts Legislature had made provision as early as 1831 for the preparation of a list of insects native to the state, as part of its natural history survey. Dr. T. W. Harris published a list of 2350 species in 1833.[10] For his labor, he was presented with several copies of the list and a copy of the natural history report to which it was appended.[11] In 1837, the Legislature appropriated funds for a more thorough survey, and Dr. Harris again was commissioned to report on entomology, especially its agricultural and economic aspects.[12] In

Thaddeus William Harris (From S.H. Scudder (ed.), Entomological Correspondence of Thaddeus William Harris, Occasional Papers of the Boston Society of Natural History *1 [1869]).*

1838, he presented a partial report, treating only the beetles.[13] An expanded report, intended for the use of farmers, was published in 1841.[14] This report was immensely successful. Indeed, it was the first practical, yet scientific, work on our native insects. In 1846, John Curtis, a renowned English entomologist, called it "the best book of the kind ever published."[15] The report was republished in 1842, again in revised form in 1852, and posthumously, with illustrations, at least six different times in 1862.[16] Dr. Harris' reputation today rests mainly upon the illustrated third edition, which was widely used until nearly the turn of the century, but which he never saw. He was paid $175 by the State of Massachusetts, which did not even cover the cost of the books he had to purchase to provide his services.[17]

Although American economic entomology had progressed by the 1840's, the insect fauna was insufficiently studied. Dr. Harris' work dealt mainly with New England insects. Elsewhere in America, insect pests were poorly known. In fact, progress in entomology lagged behind that in other branches of natural history in America and Europe. Victorians avidly studied plants, birds, shells, and other attractive natural objects as a popular, rational pastime. Like Dr. Fitch, they also studied the natural productions of the earth to approach a closer knowledge of God and to observe His beauty and perfection in nature. Entomology was neglected for several reasons. Insects were popularly considered ugly, filthy, noxious, and otherwise insignificant creatures. Their small size, large number, and supposed poisonous qualities made them difficult for the amateur to study.[18]

"An Impressive Lesson in Natural History." During the Victorian Era, natural history was a popular pastime (Original painting by Helmsly, from American Agriculturist *20:88 [1861]).*

Early progress in the study of American entomology took the form of description and classification of new species. Much of the earliest work was accomplished in Europe by Linnaeus and his followers in the latter half of the eighteenth century and early nineteenth century. Thomas Say, the first to make a determined effort to create an American literature on American insects, described more than 1500 species. His three-volume *American Entomology*, published from 1824 to 1828, was the first great work in America by an American entomologist; it was one of the first American scientific publications to win respect in Europe.[19] Even so, the rush to systematize and describe insects was well underway in Europe by the late eighteenth century, and such work lagged miserably in America for at least another 50 years. In France, Germany, Great Britain, and elsewhere on the continent, naturalists had pursued every branch of natural history with such enthusiasm that it seemed every plant and almost every insect had been discovered and described by the mid-nineteenth century.[20]

Dr. Fitch complained bitterly about the entomological ignorance of American natural historians and farmers and about the unavailability of the European literature on American insects. In 1853, he vented his views in the *Journal of the New York State Agricultural Society*.

> . . .Mauger all our vaunted light and intelligence, in this, one of the most important branches of natural science to the farmer, and one of the most interesting departments of nature's works to every studious and enquiring mind, our country at the present day is sunk in Egyptian darkness. In diffusive information, so far as respects Entomology, we are lagging far behind the subjects of several of the monarchical and despotic governments of the old world. In Germany and Prussia, countries which are regarded as much less enlightened than our own, not merely is a Professor of this science deemed indispensible in every University, and every Agricultural Seminary, but its rudiments are taught in all their primary schools. In this country, on the other hand, such a thing as a course of lectures upon this science, has never yet been delivered, except perhaps in one or two of our Universities. Indeed much of the very foundation of this science, upon this side of the Atlantic, is yet to be laid. Whole groups and families of our insects have never yet been examined. We have not even names by which to designate a considerable portion of our species. . . . In no other department of science is an exploration so urgently required, so loudly called for, as in this. Scarcely a week passes but that one or another within the circle of my acquaintance is coming to me with some insect which he has detected, preying upon some article of property; of which insect he is anxious to know the name, habits and remedies. . . . It is indeed surprising that this branch of natural science, in an economical aspect second to no other in its importance, should have remained to this day so lamentably neglected.[21]

The general unavailability of the European entomological literature undoubtedly accounts for much of the delay in American entomology. Many American insects were described in the European literature, but few of these works reached our shores in the first half of the nineteenth century. Dr. Fitch felt that a student could gather all the entomological works available in the State of New York and still not have a third of what he needed to name the insects of the State accurately. Furthermore, American museums did not provide the vast collections of identified insects that were available to European students. "And I have often thought for one to obtain accurate & full acquaintance with our insects, the only way is, to collect our specimens fully, and repair with them to Europe, where every facility is presented for ascertaining their names, — none of which facilities are here furnished."[22]

As early as 1850, Dr. Fitch indicated to T. W. Harris that there were rumblings about a legislative appropriation for an entomological survey of New York State and that Dr. Emmons' volume on the State's insects would not present enough original research to interfere with a possible new appropriation.[23] In 1853, Dr. Fitch publicly stated, "In that valuable series of volumes, the Natural History of the State of New York, we are presented with a full description of every object in the animal, vegetable and mineral kingdoms, that exists within our borders — save only our insects. This most important hiatus remains to be filled, to complete that great work and render it full and entire as it was designed to be. Each succeeding year is showing how urgently we need the information which this part of that work would furnish us. Why should its completion be longer delayed?"[24] He stated this knowing that Emmons' work on insects would soon be published, but also that it would be of little practical value. It is tempting to speculate that he was lobbying for the new appropriation so that he himself could procure the position of survey entomologist.

In the meantime, Dr. Fitch had been asked if he would be willing to take charge of entomology at the floundering Albany University — all of the arrangements until now having been temporary and experimental. He replied, conditionally, in the affirmative, but Dr. Henry Goadby, formerly of the Royal College of Surgeons in London, was employed to give a partial course on entomology with special reference to agriculture.[25] He was an elegant lecturer, but apparently not as popular as he could have been with his class of about 60 students.[26] Dr. Fitch visited Albany to learn about progress with the university project and to meet Dr. Goadby. He was disappointed to find the University in a state of uncertainty, with no prospect of sustained funding, and that Dr. Goadby had no knowledge of systematic entomology, naming his specimens only from hearsay. Also, his lectures did not touch upon agricultural entomology — only the anatomy of insects.[27]

In a more determined effort to obtain funding for a professional position in entomology, Dr. Fitch considered running for a seat in the State Legislature in the fall of 1852 so he could encourage passage of an act providing for the completion of the natural history survey. If he could not, he planned to work for the establishment of an agricultural college where he might obtain the position of Professor of Entomology. He felt compelled to obtain without further delay a means of financial support that would enable him to devote his attention to entomology.[28]

Dr. Fitch did not attain these goals, but the following autumn, Ebenezer McMurray was elected assemblyman from the first district of Washington County. Like Dr. Fitch, McMurray was an educated Salem farmer, and they had attended the Washington Academy together as youths.

They also were members of the Presbyterian Church and affiliated with the Whig Party. Indeed, Dr. Fitch had been elected an honorary member of the American Whig Society of Princeton, New Jersey, in 1847.[29] On February 25, 1854, Mr. McMurray notified the State Assembly that he would soon introduce a bill providing for the classification and enumeration of the insects, and for the appointment of a commissioner for this purpose.[30] That same day he wrote Dr. Fitch for advice. Dr. Fitch naturally suggested that the bill provide for selection of some competent and suitable person by the Regents, to be commissioned by the Governor to prepare a volume on the insects of the State corresponding with the other volumes of the "Natural History of New York." Again, he did this without admitting to the work being performed by Dr. Emmons. He also suggested that the person assigned to do the work be required to arrange for the State Cabinet of Natural History a suite of specimens described in the contemplated volume.[31]

Legislators were aware that the State natural history series was not complete as originally designed, that insects were causing great damage each year and that European governments had liberally supported entomological investigations. On April 17, 1854, the last day of the session, the State Legislature passed a general appropriation bill that provided $1000 for an investigation and description of the insects of the State, particularly those injurious to vegetation.[32] Furthermore, the responsibility for the investigation was not turned over to the natural history survey. It had been objected that the volumes on natural history, so purely scientific in character that they were unintelligible to most citizens, had little practical value. The new appropriation might also have been directed away from the survey in order to obviate further problems with Emmons' services to the State. The new entomological investigations were placed in charge of the State Agricultural Society to ensure that they would have direct reference to economy, as well as scientific accuracy.[33]

On May 4, the Executive Committee of the State Agricultural Society met in New York City and resolved to appoint Dr. Asa Fitch as Society Entomologist. The Committee gave him detailed instructions and a reminder that equal prominence should be given to economic and scientific entomology. He was to concentrate on pests of fruit trees during the first season of the appointment but also was not to neglect opportunities for studying other pests because such opportunities might not appear again for many years. He was instructed to study life histories and look at all life stages; to collect, name and describe as many insects of the State as possible; and to deposit specimens in the State Cabinet of Natural History and examples of the damage they cause in the museum of the State Agricultural Society. These instructions were so comprehensive that it seems likely Dr. Fitch himself played a role in formulating them.[34]

After receiving the appointment, Dr. Fitch went to work zealously. He dropped the town offices and other minor positions that had occupied part of his time and withdrew from nearly every other diversion to concentrate on entomology. At first he felt obliged to travel to various parts of the State, but he soon realized that there were more insects at his own doorstep than he could investigate and became reluctant to waste time travelling. He worked primarily at Fitch's Point, spending countless hours in the "bug house." For a week at a time, he would catch his sleep in an armchair, waking at intervals to note transformations in the insects before him. His meals and an extra hour after tea to read the newspaper were all the leisure he allowed himself, and even then a pocket-net was always within reach to capture insects that ventured near him.[35]

Following the State Agricultural Society's instructions, Dr. Fitch concentrated on pests of fruit trees during the 1854 season, leaving insects of grain crops, gardens, and other situations for later years. Although a fledgling field, horticulture was a rapidly growing and important industry in New York. Commercial fruit growing got underway in the 1830's and 1840's when fruit could be shipped by steam-powered transportation on land and water. However, it was not until agricultural colleges and experiment stations were established late in the nineteenth century that orchard management would receive much attention. Agricultural authors generally asserted that tillage, fertilizers, and even pruning caused trees to overbear. Attempts to control insect pests and fungus diseases were few and almost completely futile. Caterpillars, aphids, weevils, and other insects committed their plunderage unchecked by human intervention. It remained for Dr. Fitch and those who followed to study the life histories of injurious insects, describe them, and teach farmers practical entomology.[36]

Horticulture was a rapidly growing industry in New York during the nineteenth century (From American Agriculturist *21:336 [1862]).*

By late June, 1854, Dr. Fitch had found more than a dozen different species of undescribed "worms" feeding on apple foliage, and new ones were appearing every few days. He attempted to rear them to the adult stage and preserved the insects and examples of the damage they caused. This was time-consuming work, and he complained, ". . . the worms I have gathered require to be fed and nursed with even more regularity and care than a flock of Saxony sheep in winter."[37] Nevertheless, Dr. Fitch persisted with his work and presented to the State Agricultural Society his first report on the noxious, beneficial, and other insects of the State of New York, bearing the date March 14, 1855. The report received high commendation from the Society, which submitted it to the State Legislature. A select committee concluded that this able and interesting account would induce orchardists to be on the alert and save their trees from insect pests, and that the benefits of continuing the entomological investigations far outweighed the costs to the State:

> . . . Indeed, the State is *too poor* to do without the contribution which can thus be made to her resources, and science will never excuse the Legislature, if it shall refuse the appropriation for this work. It has been a topic of remark and congratulation in scientific circles of Europe, which appreciate its importance, that the additions which will be made to the science by the exploration of the insects of this State, will be of great value to the student of "American Entomology."[38]

The continuance of the appropriation for carrying on the entomological work was granted by the Legislature, and Dr. Fitch's first official report was published in 1855 in the *Transactions of the New York State Agricultural Society* for 1854.[39] It was well received by the public. Even before it was published, Dr. Fitch was elected to membership in the Entomological Society of France, perhaps the first time this honor was conferred upon an American.[40] Altogether, legislative appropriations would be made for Dr. Fitch's continuance as Society Entomologist for 19 years, through September, 1872. A meager $1000 was appropriated for his salary each year except 1868, when a 25 percent increase was approved, only to be dropped the next year. Dr. Fitch produced a series of 14 official reports that were published in the Society's *Transactions* for each year of his appointment except 1859, 1865, 1868, 1871, and 1872.

Reference Notes

[1] V. G. Dethier, *Man's Plague?: Insects and Agriculture* (Princeton, N. J.: The Darwin Press, Inc., 1976), pp. 17-42 (hereafter cited as Dethier, *Man's Plague?*).

[2] U. P. Hedrick, *A History of Agriculture in the State of New York* (New York State Agricultural Society, 1933), p. 398 (hereafter cited as Hedrick, *History*).

[3] Dethier, *Man's Plague?*, pp. 47-74.

[4] A. Fitch, Address, on our most pernicious insects, *Trans. N. Y. State Agric. Soc.* 19(1860): 588-598.

[5] *Ibid.*

[6] T. W. Harris, *A Treatise on Some of the Insects of New England which are Injurious to Vegetation*, second edition (Boston, 1852) p. 2.

[7] J. Curtis, *Farm Insects* (Glasgow and Edinburgh: Blackie and Son, 1860), p. X.

[8] M. R. Benedict, *Farm Policies of the United States, 1790-1950* (New York: Twentieth Century Fund, 1953), pp. xi-xv.

[9] M. W. Rossiter, *The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840-1880* (New Haven: Yale University Press, 1975), pp. 3-9; P. W. Bidwell and J. I. Falconer, *History of Agriculture in the Northeastern United States, 1620-1860* (Washington, D. C.: Carnegie Institution, 1925) pp. 181-182, 260-261, 306-309, 324-327, 332-334.

[10] T. W. Harris, Insects, in *Report on the Geology, Mineralogy, Botany, and Zoology of Massachusetts*, E. Hitchcock, ed. (Amherst, 1833), pp. 566-595.

[11] T. W. Higginson, Memoir of Thaddeus William Harris, in *Entomological Correspondence of Thaddeus William Harris, M. D.*, S. H. Scudder, ed. (Boston: Boston Society of Natural History, 1869), pp. xi-xxxvii (hereafter cited as Higginson, Memoir).

[12] G. B. Emerson, Introduction, in *Reports on the Fishes, Reptiles and Birds of Massachusetts*, D. H. Storer and W. B. O. Peabody (Boston: Commissioners on the Zoological and Botanical Survey of the State, 1839), pp. iii-xii.

[13] T. W. Harris, Habits of some of the insects injurious to vegetation in Massachusetts, in *Reports of the Commissioners on the Zoological Survey of the State*, E. Emmons, W. B. O. Peabody, D. H. Storer, G. B. Emerson, T. W. Harris, and A. A. Gould (Boston, 1838), pp. 58-104.

[14] T. W. Harris, *A Report on the Insects of Massachusetts, Injurious to Vegetation*, (Cambridge: Commissioners on the Zoological and Botanical Survey of Massachusetts, 1841), 459 pp. (hereafter cited as Harris, *Report*, 1841).

[15] S. H. Scudder, ed., *Entomological Correspondence of Thaddeus William Harris, M. D.* (Boston: Boston Society of Natural History, 1869), pp. 167-168.

[16] T. W. Harris, *A Treatise on Some of the Insects of New England, Which are Injurious to Vegetation* (Cambridge: John Owen, 1842), 459 pp.; T. W. Harris, *A Treatise on Some of the Insects of New England Which are Injurious to Vegetation*, second edition (Boston, 1852), 513 pp.; F. M. Brown, The third edition of Thaddeus William Harris' "Treatise on some of the insects injurious to vegetation," 1862, *Entomol. News* 86 (1975): 65-68.

[17] Harris, Report, 1841, p. vi; Higginson, Memoir.

[18] W. Kirby and W. Spence, *An Introduction to Entomology; or, Elements of the Natural History of Insects* (Philadelphia: Lea and Blanchard, 1846), pp. 37-66. (first published in London, 1815-1826).

[19] H. B. Weiss and G. M. Ziegler, *Thomas Say, Early American Naturalist* (Springfield, Ill.: Charles E. Thomas, 1931), pp. 190-192.

[20] A. Fitch, untitled manuscript lecture on entomology, 1853, pp. 15-16, New York State Museum.

[21] A. Fitch, Apple tree pests, *J. N. Y. State Agric. Soc.* 4(1853): 36-39 (hereafter cited as Fitch, Apple tree pests).

[22] A. Fitch, untitled, undated manuscript, New York State Museum.

[23] A. Fitch to T. W. Harris, letter dated 13 Nov. 1850, file bMu 998. 10. 2, Museum of Comparative Zoology, Harvard University.

[24] Fitch, Apple tree pests.

[25] Anon., University of Albany, *Cultivator* 9(1852): 64.

[26] A. Fitch to T. W. Harris, letter dated 23 Feb. 1852, file bMu 998. 10. 2, Museum of Comparative Zoology, Harvard University.

[27] A. Fitch to T. W. Harris, letter dated 6 Apr. 1852, file bMu 998. 10. 2, Museum of Comparative Zoology, Harvard University.

[28] A. Fitch to T. W. Harris, letter dated 11 Aug. 1852, file bMu 998. 10. 2, Museum of Comparative Zoology, Harvard University.

[29] Asa Fitch Diary, 8 Nov. 1842, 24 July 1847, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University; obituaries of Washington County, N. Y. & neighboring towns, 1866-1895, Newspaper clippings, 5: 1651, New York State Library.

[30] Journal of the Assembly of the State of New York; at their Seventy-seventh Session, 1854, p. 388.

[31] A. Fitch to E. McMurray, letter dated 21 Mar. 1854, Dr. Asa Fitch Historical Society, Salem, N. Y.; A. Cormier, Dr. Asa Fitch Society, *The Journal Press: The Greenwich Journal, The Salem Press*, 15 Mar. 1984, p. 7.

[32] Laws of New York, Chapter 397, 1854.

[33] New York State Assembly Document 137, 1855.

[34] W. Kelly and B. P. Johnson, Entomological survey, *Trans. N. Y. State Agric. Soc.* 14(1855): 700-703.

[35] C. Johnson, History of Washington Co., New York (Philadelphia: Everts & Ensign, 1878), p. 187.

[36] Hedrick, *History*, pp. 380-404.

[37] A. Fitch, Entomological survey, *J. N. Y. Agric. Soc.* 5(1854): 36-37.

[38] New York State Assembly Document 137, 1855.

[39] A. Fitch, Report, *Trans. N. Y. State Agric. Soc.* 14(1855): 705-880.

[40] Anon., Continuation of the entomological survey by Dr. Fitch, *J. N. Y. State Agric. Soc.* 6(1855): 4; Anon., [untitled], *Cultivator* 3(1855): 160.

CHAPTER ELEVEN

Dr. Fitch's Contributions to Economic Entomology

The Fitch entomological reports, the first series of the kind published in the United States, became models for later entomologists, including Walsh, Riley, Packard, Thomas, and Lintner. In fact, Dr. Fitch essentially established the model for professional entomologists in government service.[1] His reports, based largely on the results of original observations, were arranged to be useful to both scientists and farmers. Instead of treating insects in a scientific, systematic order, Dr. Fitch arranged them by the crops they destroy. For example, in the first report, he treated mostly fruit tree pests. Beginning with the apple, he treated in succession insects affecting the roots, trunk, twigs, leaves, flowers, and fruit. In the same order, he treated insects that occur on pear, peach, plum, and cherry trees. Dr. Fitch endeavored throughout to couch his reports in plain, familiar language, avoiding unnecessary technical terms. His concern with science for the common purposes of life, which he absorbed from Professor Eaton, is plainly evident.

The domestic and foreign press, including newspapers and agricultural and scientific journals, frequently reviewed and excerpted the Fitch reports. Rarely did they give less than the highest praise. The editor of the *Germantown* [PA] *Telegraph* described the second report as "a searching, intelligent and valuable work" and complimented the layout, illustrations, and simplicity of composition.[2] In 1858, the State Agricultural Society reported having received convincing evidence of the value of Dr. Fitch's work from every corner of the State, as well as from other states and foreign countries. Constant requests were made for the reports as soon as they were issued. Some of the leading farmers of New York State advised the Society of the great advantages they realized by paying careful attention to Dr. Fitch's recommendations and suggestions.[3]

Illustration of the maple leafcutter, Parademensia acerifoliella *(Fitch), and the damage it causes from Dr. Fitch's second report on the noxious, beneficial and other insects of the State of New York (From* Transactions of the New York State Agricultural Society *15:pl.4 [1856]).*

The State Legislature periodically had most of Fitch's reports reprinted. For example, in April, 1856, the Assembly and Senate concurred on a resolution to print and bind together the first and second reports. A total of 500 copies were ordered for the author, 1000 for the State Agricultural Society, and 24 for each member, officer, and reporter of the legislature.[4] In London, Professor John Lindley, a distinguished botanist and horticulturist – and principal editor of the *Gardeners' Chronicle* – praised the volume. He considered the style and layout to be the best way of rendering entomological information useful to the mass of mankind and regretted that the observations of Curtis and Westwood in England were not collected and arranged similarly. He regarded Dr. Fitch as an observer of a high order and complimented his consistency in applying basic natural history to the common, practical purposes of life.[5]

In Paris, in 1858, the Section of Natural History of the Imperial and Central Society of Agriculture proposed that the Society award Dr. Fitch a gold medal with a bust of Olivier de Serres, Father of French Agriculture, on one side and Dr. Fitch's name on the other. The Society concurred, and the medal was awarded in acknowledgment of the Society's duty "to encourage all good works undertaken in such a useful direction."[6]

Dr. Fitch's work continued to attract attention, and the State Agricultural Society was justly proud. In 1861, the Society reported that every year the entomological work was appreciated more and more. Requests for Dr. Fitch's sixth report came from every section of country and most of the entomological associations of Europe. The Society was gratified to learn that the reports were instrumental in turning the attention of many citizens of the State and the country to entomology.[7]

Indeed, the Fitch reports also turned the attention of Europeans to the scientific study of insect pests. Although for decades Europeans had an edge in describing and classifying insects, Americans were now gaining an edge in economic entomology. In 1857, in the introduction to his *Farm Insects*, John Curtis, an English entomologist, complained of the backwardness of his own people in pursuing applied entomology. He pointed out the good work done by Harris and Fitch in America, Guérin Méneville and Bazin in France, Passerini in Italy, and the entomological savants of Germany.[8] In 1865, also in England, the *Mark Lane Express* reported that in the United States much more attention was given to practical entomological studies and complained that it had been some time since anything was done in this direction by the Royal Agricultural Society of England.[9]

A multitude of similar commendatory notices could be mentioned, but it is apparent that, working in scientific isolation at his rural abode, Dr. Fitch had become preeminent among the world's pioneer entomologists. His research and reports were so highly regarded abroad that, in addition to the Entomological Society of France, he was elected to membership in the Entomological Societies of Philadelphia, Germany, and Russia, and other scientific societies at home and abroad. He felt that he had little time for other than the most important correspondence, but among his correspondents were such eminent entomologists as Harris, Herrick, Osten Sacken, Curtis, Westwood, Gerstacker, and Riley.[10]

The enduring value of the Fitch reports is evident from the fact that they were in demand decades after they were written. In 1880, C. V. Riley stated that they should be republished because of their scarcity and importance.[11] As late as 1891, F. W. Goding considered Fitch's 14 reports among the first to be placed in an entomologist's library and prized possessions of intelligent farmers. He called them a grander monument to Dr. Fitch than any that could have been constructed from marble or brass.[12]

As late as 1936, H. B. Weiss wrote of the Fitch reports, "They are indispensible to American entomologists and are frequently utilized at present. Much of their information has been reprinted over and over by later authors until the original source has been lost sight of."[13] This habit of taking Dr. Fitch's word unquestioned, however, has sometimes led to the preservation of inaccuracies. In his third report, Dr. Fitch gave his opinion that bot flies castrate their squirrel hosts. This remained established dogma for over 120 years, until in 1981 it was questioned and demonstrated to be unsupported by evidence.[14]

During his professional career as New York's official entomologist, Dr. Fitch served as entomological correspondent for some of the popular farm papers. He wrote a series of more than 30 articles for Luther Tucker's immensely successful papers, the *Country Gentleman* and the *Cultivator*. Through these columns, he obtained wide popular exposure and brought entomology to the attention of the "dirt farmer" and the scientific agriculturist. This exposure served his own aim to collect information on noxious insects from farmers around the country.[15]

Dr. Fitch also published occasional entomological articles in other farm papers, such as the *American Farmer*, *Ohio Cultivator*, *Genesee Farmer*, *Boston Cultivator*, *American Agriculturist*, and *Prairie Farmer*, and in local newspapers. His original entomological publications, including the official reports, number more than 140. Counting the reprints, revisions, extracts, and compilations of original articles, the publications number over 220, thus giving some indication of their popularity and demand. Dr. Fitch apparently never published articles in the scientific or entomological journals of his day, such as the *American Journal of Science* or the *Practical Entomologist*, and he made no apology for describing and naming new species in the popular press, probably because the need for names for our American insect species was so great at that time.

Although much of Dr. Fitch's work on economic entomology has been superseded, it has had a lasting value as a stimulus and model for subsequent workers, and it aroused the attention of citizens and governments to the importance of entomology. Dr. Fitch publicized the science, stressing its importance for the common purposes of life. His use of simple language in scientific writing was followed by Walsh, Riley, Lintner, and others. The *Practical Entomologist*, a short-lived bulletin founded by the Entomological Society of Philadelphia in 1865, endeavored to reach the practical farmer, and its editors avoided all technical terms as nearly as possible.

The fact that Dr. Fitch's work served as a model appears frequently in the literature. Lintner claimed that Fitch's reports led the way for similar investigations in other states;

he recognized that the interest they aroused influenced the valuable works of Riley in Missouri and Walsh and LeBaron in Illinois.[16] After reviewing the universal good that emanated from Fitch's work, Walsh called for Illinois to furnish a "Bugmaster-general" to fight a large and destructive army – the Noxious Insects of the United States.[17] He publicized the dangers of insect pests so well that the Illinois State Legislature created the office of State Entomologist at its 1866-1867 session, and he was appointed to it. As the years passed, the influence of Dr. Fitch's appointment was felt widely. In 1891, F. W. Goding summed up the situation:

> The importance of the study of entomology, in its relations to agriculture and horticulture, has been fully recognized by most of the governments in the civilized world, and nearly all of them have employed agents or commissioners to investigate the depredations of various noxious insects, with a view to discover a means of averting or remedying the great damage done by them. The State of New York early appreciated the need of such line of investigation, and in 1854 made an appropriation for that purpose. Dr. Fitch's appointment followed, and his seventeen years of unremitting toil evinced the wisdom of the move.[18]

Dr. Lintner also remembered to credit the State Agricultural Society:

> The labors of Dr. Fitch will long be held in grateful remembrance, and the New York State Agricultural Society may justly lay claim to having, by its action in connection therewith, done very much toward the promotion of Entomological research, not only within the immediate sphere of its labors, but throughout the Union, and to science at large – coextensive with the civilized world.[19]

In Washington, D. C., Dr. Fitch's appointment received national recognition at the 1954 centennial celebration of the establishment of entomological research as an essential government function.[20]

Perhaps an indirect result of Dr. Fitch's labors was the establishment of a teaching center for entomology. Dr. Fitch rarely lectured to students, although he occasionally spoke to farmers at the State Agricultural Society's annual fairs and meetings, and in 1860 he gave a course of six lectures on economic entomology at Yale University.[21] However, it was a fortunate circumstance that his work fell under the eyes of Ezra Cornell of Ithaca.

In 1862, Cornell was president of the State Agricultural Society and a trustee of the State Agricultural College in Ovid. The Society had fought for the establishment of the college, but it was languishing from lack of funds. The Morrill Land Grant Act, which Congress had just passed, appropriated public lands in "aid of instruction in agriculture and the mechanic arts." Andrew Dickson White, a member of the New York State Senate, had in mind a great American university. Like the one that James Hall had envisioned for Albany over a decade earlier, it would be more comprehensive in plan than any yet attempted, and science and technology would take their proper stand alongside philosophical, professional, and literary studies. White persuaded his fellow senator Ezra Cornell to grant funds in addition to the money realized from the sale of Morrill Act lands for the establishment of such a university. At Cornell's suggestion, the State Legislature transferred the State Agricultural College to Ithaca, and Cornell donated his farm and a half million dollars to the cause. The faculty of the new university was organized in 1867 by the appointment of A. D. White as the first president.[22]

As a young man, John Henry Comstock purchased a superbly illustrated copy of T. W. Harris' *Insects Injurious to Vegetation* and quickly became enraptured with entomology. Cornell University soon opened, and Comstock was drawn to it by the announcement that a professorship in entomology would soon be filled. He entered the university in the autumn of 1870. No professor of entomology had been named by 1872, so several students who were aware of Comstock's recently acquired knowledge of the subject asked that the university permit him to present a course of 10 or 12 lectures on economic entomology. The trustees consented. These informal lectures led to his appointment as instructor of entomology in 1873. In Comstock's junior year, a tiny laboratory was established for him in the University's bell tower.[23]

Comstock was eager to learn how to do his work. Up to the time he was made instructor of entomology, he had not had any assistance in entomology, so he made a pilgrimage to Salem to visit Dr. Fitch. Years later he recalled that trip as one of the bright experiences of his career. He found Dr. Fitch a genial old gentleman and recalled the remarkable entomological library in his office. When he talked with Dr. Fitch about methods and how to go to work, the doctor replied, "The way to do is to sit down and study an insect." It always remained a blessed memory to Comstock to have seen "that grand old man."[24]

Comstock graduated in 1874 and was appointed assistant professor of entomology in 1876. He was one of the first teachers of economic entomology in the United States, and through his long career at Cornell, he strongly influenced the development of American entomology. He was a dedicated teacher and wrote several books on insects and spiders. It has been claimed that he taught more than 5000 students. Certainly, generations of students have been nurtured on his books.[25]

In his publications, Dr. Fitch treated numerous injurious insect pests of New York State in detail. He studied life histories, described and named new species, searched for practical and effective control strategies, and taught farmers practical entomology. Most of his control methods have been superseded, and although much of his lasting reputation as a scientist rests on his careful life history studies, it is interesting to briefly review some of them and the cultural milieu in which they were developed. Modern insect control methods evolved partly from them, and some of the methods he employed were harbingers of future directions.

With the rapid development of the agricultural press early in the nineteenth century, farmers and gardeners found ample opportunity to address editors with requests for, or offers of, advice concerning agricultural problems. Home cures for the ever-increasing depredations of insects regularly debuted in the farm papers. By the mid 1860's it was estimated that at least 10,000 remedies had been published in the agricultural papers.[26] These dusty papers remain a record of the concerns of the farmers of the nineteenth century, and from them it is possible to glean an idea of the insects that were important and the remedies that were commonly applied against them.

Grain and fruit pests received more attention than others. Frequently some noxious material was used to kill the offending insects or to protect the plants — charcoal, soot, ashes, road dust, slaked lime, cow dung, urine, whitewash, scotch snuff, camphor, tar, turpentine, soap, pepper, elder leaves, walnut leaves, quassia, hellebore, and others. Except for sulfur, and later arsenic, the first effective insecticides were plant products, including nicotine, hellebore, and pyrethrum. The materials were used individually or in mixtures, concocted or decocted, and they were dusted, spread, painted, syringed, burned, or inserted into, onto, or near the afflicted vegetation.

The authors of the remedies often supported their claims enthusiastically, explaining in their letters to the editors how efficacious the remedies had been in a single trial, and frequently ending their entreaties with "Try it!" or "Worth trying!" Some even tried to market their nostrums. It is not surprising that the disgruntled farmer, having tried a few of these sure cures and having found them worthless consigned entomological devotees "to a place which it would shock polite ears to mention more explicitly."[27] Of course, entomologists recognized the faults of human testimony, the insufficient regard for multiple observations, and the tendency to apply a remedy when the insect damage was most obvious and the satiated culprit had finished feeding. Dr. Fitch and others were diligent in trying to eradicate the entomological charlatans, appropriately named *"Humbuggus entomologicus."*[28]

Entomologists of the era felt confident that successful insect control depended on a knowledge of natural history. When Dr. Harris revised his classic report in 1852, he wrote, "A familiar acquaintance with our insect enemies and friends, in all their forms and disguises, will afford us much help in the discovery and proper application of the remedies for the depredations. . . ."[29] The early entomologists realized there was no panacea — that patient investigation and experiments were needed to combat the onslaught of insect enemies and to discredit the charlatans and humbugs.

Explaining his philosophy of insect control at the 1859 annual meeting of the State Agricultural Society, Dr. Fitch said he could not believe Divine Providence had placed any insect pest in our world without endowing man with sufficient intelligence to discover a method for frustrating or overpowering it. He firmly believed there is no injurious insect that cannot be overcome if we are sufficiently acquainted with its natural history. We must be able to detect an assailable point and devise some measure to destroy the insect or shield the vegetation from its attacks. "We shall discover that, although he may be invulnerable in every other part, no aegis protects his heel, and if we strike Achilles there, we inflict a death-wound."[30] This emphasis on bionomics led to many useful and novel insect control strategies, some of which are familiar today: adjustment of planting times, manuring, selection of hardy varieties, manipulation of predators and parasites, baiting, and many more.

The continued ravages of the wheat midge in this country during the early nineteenth century severely affected wheat culture. Numerous economic accounts of the midge appeared; one of the most detailed and exact was the nearly 90-page discussion in Dr. Fitch's sixth report.[31] New York State was prominent as the scene of the depredations of this insect. Statistics returned to the State Agricultural Society in 1854 showed that New York that year lost $15 million due to the midge. The pest caused many to abandon wheat culture.[32]

When he published his first paper on the "wheat fly" in 1845, Dr. Fitch believed the midge to be an old world species, *Contarinia tritici* (Kirby), known in Great Britain for more than a century as an occasionally serious pest. In the mid-nineteenth century it was detected in northern France. When his 1845 publication reached Europe, the eminent French entomologist C. B. Amyot dissented from the opinion that the wheat midges of the two continents were the same. Dr. Fitch sent specimens to Amyot, who compared them with European specimens, found them identical in every minute detail that the microscope revealed, and concluded that they were, indeed, the same species.[33]

Today it is still not certain which species Dr. Fitch considered the wheat midge. In 1912, Ephriam Porter Felt, the distinguished State Entomologist of New York and a specialist on the classification of gall midges, studied specimens labelled "wheat midge" by Dr. Fitch. He concluded that they belonged to an American species new to science, which he named *Prodiplosis fitchii* in honor of Dr. Fitch. The European species, *Sitodiplosis mosellana* (Géhin), recently had been reared from New York wheat-chaff, and this is the species now regarded as the wheat midge. Dr. Felt, however, pointed out that available evidence was insufficient to determine which of the species had been referred to so frequently in earlier economic literature. It could even have been a third species that he described and named *Itonida tritici*, or it could have been all three species or some other form – but certainly not the European *Contarinia tritici*. This species was characterized as having an especially long ovipositor, which was not present in any of the American wheat midges. Dr. Fitch might or might not have been correct in assuming he was working with an introduced European species.[34]

That Dr. Fitch considered the wheat midge a European immigrant led him to suggest one of his most innovative and remarkable proposals for insect control. He long knew from foreign accounts that the midge was much more destructive to crops in America than in Europe. After the disastrous harvest of 1854, he weighed the facts bearing upon the situation. In his 1845 paper he had stated that population crashes of the pest, which followed soon after a season in which it had been extremely annoying, were caused by "that beautiful provision of nature . . . that an undue increase in any of the species of the animal or vegetable world never takes place, without being speedily succeeded by a corresponding increase of the natural enemies and destroyers of that species, whereby it again becomes reduced to its appropriate bounds."[35] In Europe there were effective parasites of the midge, and following a year of heavy infestation the fields would abound with parasites, and the midges would be scarce.

> But in this country no such parasitic destroyer appears to quell it, and I have hence supposed that we have received this insect from Europe, whilst its parasitic destroyer has not yet reached our shores. Thus we are hence without nature's appointed means for preventing the undue multiplication of this insect. We have received the evil without the remedy; and hence it is that this little creature revels and riots in this country without let or hindrance.[36]

Dr. Fitch concluded that it was his duty as Entomologist of the State Agricultural Society to obtain live specimens of the European parasites. He had already corresponded with John Curtis, president of the Entomological Society of London, so he wrote to him about this subject in May of 1855. When Mr. Curtis put the matter before the Society at its next meeting, it led to a lively discussion and a resolution that any member encountering parasites forward them to Dr. Fitch. Unfortunately, nothing came of this resolution. Nevertheless, Dr. Fitch's proposal was perhaps the first concrete suggestion to conduct "conventional" biological control, or the importation of insect parasites from a foreign land to help suppress an immigrant pest.[37]

A report on Dr. Fitch's biological control proposal appeared in the November, 1857, issue of the *Journal of the New York State Agricultural Society*, but it apparently attracted little attention.[38] Dr. Fitch mentioned more about his proposal in his sixth official report, published in the Society's *Transactions* in 1861. This account was noticed in the preliminary report on the 1860 census, published in 1862. The Census Office inappropriately complimented the State Agricultural Society for its philanthropic spirit in having "introduced into this country from abroad certain parasites which Providence has created to counteract the destructive powers of some . . . depredators."[39] In 1867, B. D. Walsh, editor of the *Practical Entomologist*, recorded his opinion in his usual stinging style:

> The real truth of the matter is, that the New York State Agricultural Society has done nothing of the kind, which the U. S. Census asserts that it has done; though, like certain other Societies, it has got the credit of actually doing a thing, because it simply talked about doing it. Unless my memory fails me, Dr. Fitch stated that he had written to that distinguished English Entomologist, Mr. Curtis, to send him living specimens of the parasites that infest the Wheat Midge in Europe, but that, as might have been naturally expected, no practical results followed from that application. How could it be otherwise? Who, in this dirty, selfish, mean little planet of ours – which, as Sterne has suggested, seems to have been made out of the refuse clippings from larger and better worlds – ever gives something for nothing?[40]

Walsh then wrote an imaginary letter sarcastically setting down what Dr. Fitch might have written to Mr. Curtis.

> Think my dear sir, for one moment, of our Midge-ridden farmers in New York! Think that, by sacrificing a few months of your time, and a few thousand dollars out of your own private pockets, you will put millions of dollars into the pockets of our wealthy State, and, eventually, hundreds of millions into the pockets of the whole United States! With your well-known philanthropic sentiments, can you possibly, for a single moment, resist the temptation of making the American people more rich and more prosperous than they already are?
>
> You will please distinctly to understand, that neither the Congress of the United States, nor the Legislature of the State of New York, nor the New York State Agricultural Society, have appropriated one cent towards the furtherance of the above very important subject. It is possible, therefore, that in addition to your own personal expenses, you may have to pay, out of your own pocket, the freight and express charges on the packages of living Parasites sent from time to time to us. But even if you have to do this, think of the glory you will acquire by annually, for all time, adding hundreds of millions of dollars to the profits of the great American nation![41]

Of course, Walsh's purpose in writing this imaginary letter was to emphasize his criticism of government inactivity regarding Dr. Fitch's simple, elegant, and sensible plan.

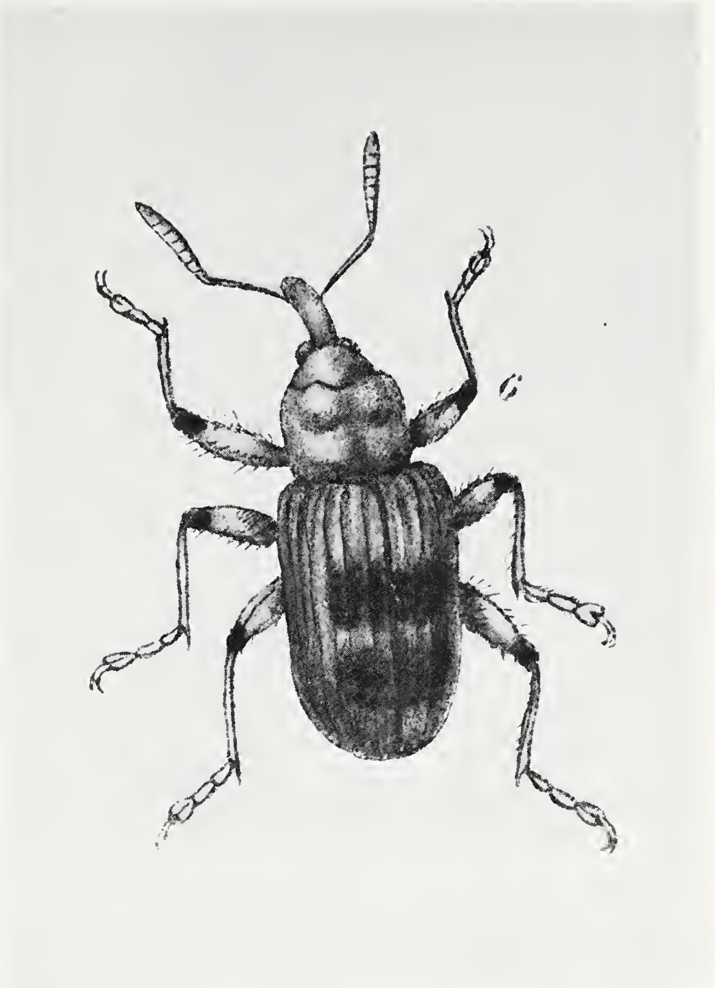
> Although the plan was long ago recommended by some of the best entomologists in the country, Dr. Fitch for example, it has never been adopted, and probably never will be. Why? Because our Legislatures think that insects are such very minute objects, that they are unworthy of notice. . . .[42]

That Walsh and Fitch were exceptionally far-sighted is illustrated by another article by Walsh in the *Practical Entomologist* in 1866. Walsh pointed out that Dr. Fitch had observed that no American plant-feeding insect attacks toadflax, a European weed naturalized in much of North America. Dr. Fitch had speculated on the propriety of importing European insects known to feed on it and had also suggested importing some or all of the three parasitic insects known to control the wheat midge in Europe. Walsh said that we should not stop here, that the principle is of general application. ". . . Whenever a Noxious European Insect becomes accidentally domiciled among us, we should at once import the parasites and Cannibals that prey on it at home. . . . To attempt to fight them with the poor old-fashioned indigenous Cannibals and Parasites of America, is like sending out a fleet of old-fashioned wooden ships to oppose a fleet of ironclads."[43]

Because of Walsh's constant promotion of Dr. Fitch's idea, the first experiments in biological control by parasite importation were begun in the 1870's, primarily by Charles Valentine Riley.[44]

Around 1860 the midge began to disappear from the wheat fields; it became progressively less destructive and ever since has been only local in its attacks. Dr. Fitch believed the United States had had the worst of this pest and that its career would be analogous to that of its predecessor, the Hessian fly, which declined after several years of spreading over the country and causing havoc in wheat fields. To him it seemed a law of nature that when an insect is introduced into a country with a favorable climate and vegetation it immediately multiplies and seizes a place in the arrangements of nature that does not belong to it and that it cannot continue to occupy.[45] In reality, wheat growers had begun to employ various methods to circumvent the midge, many of which had been endorsed by Dr. Fitch. They included deep plowing, crop rotation, late sowing of spring wheat, use of resistant varieties, and burning infested chaff and screenings after threshing the grain.[46]

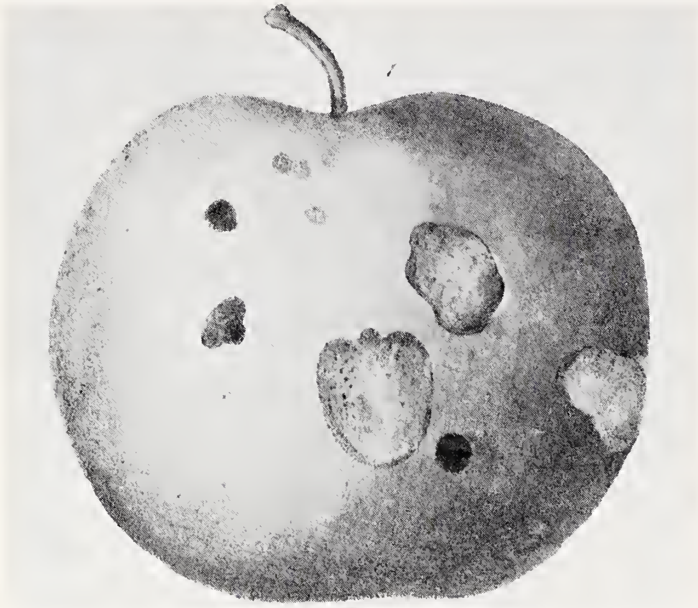
Pests of fruit trees occupied Dr. Fitch's attention continually, and he discussed them extensively in his publications. At one of his Yale University lectures in 1860, he stated that there were 60 known insect pests of apple, 12 of pear, 16 of peach, 17 of plum, 35 of cherry, and 30 of grape. Prominent among these was the plum curculio, which Dr. Fitch stigmatized as the country's worst insect pest.[47]



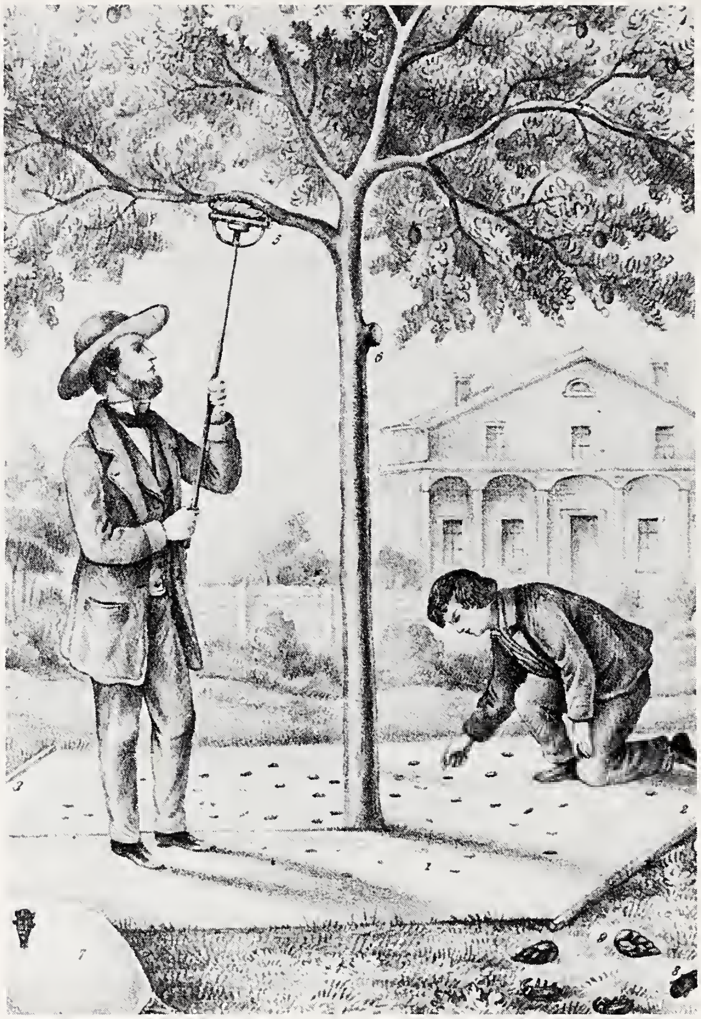
The plum curculio, Conotrachelus nenuphar *(Herbst) (From I.P. Trimble,* A Treatise on the Insect Enemies of Fruit and Fruit Trees *[1865]).*

The plum curculio is a native weevil that formerly fed on wild plum, hawthorn, and crabapple, but now also attacks cultivated plums, apples, peaches, cherries, and other fruits. In spring, the adult emerges from overwintering quarters and feeds on leaves and blossoms until the developing fruit appears. The female cuts through the skin and deposits a tiny, white egg, which she pushes to the bottom of the cavity with her snout. In front of the cavity she cuts a crescent-shaped slit that extends obliquely under the egg, leaving it in a flap of flesh. The larva feeds on the flesh for several weeks before maturing. Oviposition and feeding scar the fruit, which often becomes misshapen and drops prematurely from the tree.

According to Dr. Fitch, the plum curculio was recognized as a pest as early as the mid eighteenth century, and its ravages steadily increased early in the nineteenth century. Some of the early suggestions for its control provide a reminder of how desperate growers had become. Some felt that building a tight board fence nine feet high, furnished with a tight gate, around the orchard would provide relief. Others directed orchardists to pave the ground beneath the trees or apply salt plentifully at any season.[48] Dr. Fitch found that the most common remedy was one that had long been used in Europe against similar insects and had been brought to public notice in this country by David Thomas, chief engineer of the Erie Canal west of Rochester and a distinguished horticulturist who frequently published in Rochester's widely circulated *Genesee Farmer*.[49] Thomas directed growers to spread sheets under the infested tree, then strike the trunk with a club or mallet. The sudden jar causes the weevils to fall to the sheets, where they can be picked up and destroyed. Due to the efforts of entomologists and horticulturists, this remedy became popular by the 1860's, and it has been pronounced a landmark in insect control because it was perhaps the first sensible recommendation for the control of orchard pests.[50]



An apple scarred by the plum curculio (From I.P. Trimble, A Treatise on the Insect Enemies of Fruit and Fruit Trees *[1865]).*



Shaking a tree to release the plum curculio and gathering the weevils, which will be destroyed (From I.P. Trimble, A Treatise on the Insect Enemies of Fruit and Fruit Trees *[1865]).*

Dr. Fitch reviewed one other remedy for the curculio that was making the rounds of the agricultural press. A Mr. Cummings, of the *New York Observer*, suggested that as soon as the curculio appears a garden syringe should be used to drench plum foliage with a mixture of four ounces of sulfur, a pound of whale oil soap, four gallons of lime water, and four gallons of strong tobacco water. From his experience with other insects, Dr. Fitch felt that the tobacco water and whale oil soap would be useful, but he doubted that the lime water and sulfur made the mixture more efficacious.[51]

Sulfur had long been popular as an antidote to many insect pests. One of the most persistent recommendations for controlling caterpillars on fruit trees directed the grower to bore an auger hole in the trunk or main root of the infested tree, fill the hole with sulfur, and then plug it with wood from the same tree. The auger-hole remedy dates back at least to the seventeenth century, when brandy or rum was used instead of sulfur.[52] Early in the nineteenth century sulfur became the chemical of choice due at least in part to the experiments of George Webster of Albany, which were publicized in the *Memoirs of the Board of Agriculture of the State of New York* in 1823 and extensively copied into other publications.[53]

Webster's neighbors had been cutting down their caterpillar-infested trees because they were worried that the insect was that very venomous reptile called "the asp." In 1805, a large elm tree on his property was nearly defoliated by caterpillars. A passerby accosted him and said, "George, tis a pity to lose so fine a tree. . . . Send and get a little sulfur, and bore into the tree about six inches, and fill it with sulfur, and my word for it, not a caterpillar shall be seen after forty-eight hours." Webster did as he was instructed, later reporting there was not "the vestige of a caterpillar" on the tree in less than 48 hours. He suggested that two men could treat 200 trees in a day and speculated that the treatment would also prevent "the black rust" in peach, plum, and cherry trees.

It was readily apparent to Dr. Fitch that many people were assured of this remedy's efficacy simply because the "worms" disappeared from the infested trees within a day or two after it was applied. He pointed out the fallacy in this argument: larvae of insects generally become most voracious and cause the most damage just as they are arriving at maturity. When fully grown they are most noticeable. Having nearly completed their growth, they are ready to leave the tree within a few days. People not conversant with the habits of the pests supposed their remedy drove them from the tree, but in reality it is their natural habit to abandon the tree at this time.[54]

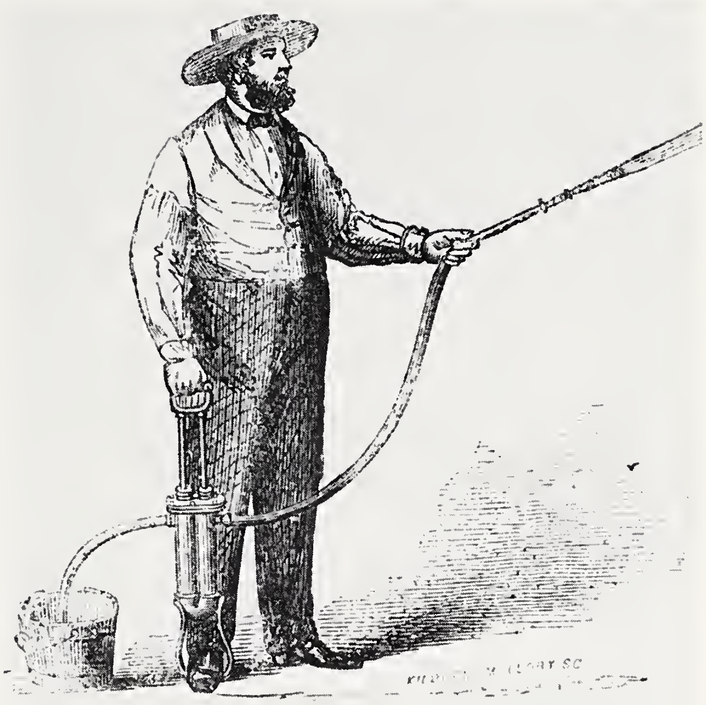
Dr. Fitch experimented by placing one caterpillar-infested cherry twig in a cup of moistened sulfur and another in a cup of water. Caterpillars on the twig in the cup of sulfur matured a third sooner than the others, and Dr. Fitch became convinced that the sulfur-plug remedy was nonsense. As news of the remedy's supposed efficacy spread and new variations appeared, Dr. Fitch, B. D. Walsh, and others fought back the humbugs. Dr. Fitch was particularly irritated with the supposed necessity of making the plug from wood of the same tree. In 1853, after an educated citizen suggested this remedy, he exhorted, "Methought he ought to have added, that the hole should be made with 'a silver bullet,' or at least that this operation should be done 'in the old o' the moon.' "[55]

One offshoot of this traumatic cure for infested trees involved driving nails into them. Mr. Walsh, in his familiar style, made a mockery of this cure in 1866:

> It is singular what a propensity just now men have to drive nails into fruit-trees, with the idea of benefiting them. some indeed prefer boring augur [*sic*] holes, but the nails seem the almost universal panacea of the day. Probably in 1867 it will be the fashion to take a draw knife and shave all the bark off the trees in every orchard; and in 1868 we shall reach the millenium of horticultural perfection, and dress off all our fruit-trees with a jack-plane to some mathematical figure.[56]

Dr. Fitch could confidently recommend only the destruction of eggs or young larvae in winter or early spring to control caterpillars on fruit trees.[57]

Dr. Fitch constantly encouraged the public to experiment with various means of subduing insect pests or shielding plants from their ravages. He also long felt a need for an efficient device for drenching trees and herbs with vegetable infusions and chemical solutions. He wanted an instrument "more capacious than the syringe and more economical than the garden engine." Among the many agricultural inventions then appearing was a hand pump that at first was labelled a "fire annihilator."[58] Capable of propelling water by both the upward and downward stroke of the handle, it could be conveniently carried around with a bucket of water, and it could throw water up to the roof of a two-and-a-half story building.


The "Hydropult."

A bucket pump manufactured by the American Hydropult Company was advertised as a "new way of attacking insects" (From American Agriculturist *19:236 [1860]).*

Upon receiving one of these implements for inspection, an assistant on the staff of the *American Agriculturist* aptly named it the "Hydropult." Finding that the instrument filled his need, Dr. Fitch encouraged the farmer to use it to treat pest insects "to a dose of tobacco water, aloes, quassia, and other bitter infusions, soap suds, weak lye, lime water, etc., and long before he has exhausted the pharmacopeia, we think he will come to something that is such an efficacious remedy for this insect, that, elated with the discovery, he will immediately let the world know it. . . ."[59] Finding Dr. Fitch's testimony encouraging, the American Hydropult Company of New York City started running advertisements in the *American Agriculturist* promoting their bucket pump as a "New Way of Attacking Insects."[60]

In 1875, the Colorado potato beetle reached Washington County.[61] Dr. Fitch was prepared. Four years earlier he had purchased four pounds of Paris green at a drug store, expecting that the beetles would soon reach his fields.[62] Paris green was an arsenic-laden artists' pigment that tradition says was first produced commercially in Schweinfurt, Germany, in 1814.[63] In France, it came into use as a control for vineyard pests, and in America in the 1860's it was applied against the Colorado potato beetle, which was spreading eastward at an alarming rate. The introduction of Paris green as an insecticide launched a new era in the use of toxic substances for commercial purposes. One of the earliest strictly synthetic insecticides, it was the first such substance to be produced and traded on a significant scale. Thus, the insecticide era was underway shortly before Dr. Fitch retired from public service.[64]

More than a century later it is impossible to estimate the economic impact of Dr. Fitch's work on insect control. Even estimates made in the nineteenth century seem frivolous and unsubstantiated. Before Dr. Fitch's sixth report was published, B. P. Johnson wrote, "The saving to many of our farmers and horticulturists, by observing the directions given in the reports published, have already amounted, we are confidently assured, to more, in a pecuniary point of view, than the entire expenditure made for the promotion of agriculture by our State government."[65] Around 1868, one senator gave his "deliberate opinion" that the writings of Dr. Fitch had annually saved New York State the sum of $50,000.[66] Whatever the actual case, Dr. Fitch's influence certainly went far beyond the sum he saved the farmers of New York State.

REFERENCE NOTES

[1] L. O. Howard, A history of applied entomology, *Smithsonian Miscellaenous Collections* 84: 35-50; J. H. Perkins, *Insects, Experts, and the Insecticide Crisis* (New York: Plenum Press, 1982), p. 243.

[2] P. R. Fries, Transactions of the New York State Agricultural Society, for 1855, *J. N. Y. State Agric. Soc.* 7(1857): 85.

[3] B. P. Johnson, Report of the Executive Committee for 1858, *Trans. N. Y. State Agric. Soc.* 18(1859): 3-31.

[4] Laws of New York, 79th Session, Resolution of 5 Apr. 1856 (Assembly), 7 Apr. 1856 (Senate), p. 363.

[5] J. Lindley, Fitch's First and Second Reports Upon Noxious, Beneficial and Other Insects of the State of New York, *J. N. Y. State Agric. Soc.* 8(1858): 102.

[6] Anon, [untitled], *J. N. Y. State Agric. Soc.* 9(1858): 10-11.

[7] B. P. Johnson, Report of the Executive Committee for 1860, *Trans. N. Y. State Agric. Soc.* 20(1861): 3-29.

[8] J. Curtis, *Farm Insects* (Glasgow and Edinburgh: Blackie and son, 1860), pp. xi-xii.

[9] Anon., Entomology in America, *J. N. Y. State Agric. Soc.* 15(1865): 40.

[10] J. A. Lintner, *First Annual Report on the Injurious and Other Insects of the State of New York* (Albany, 1882), pp. 323-324 (hereafter cited as Lintner, *First Annual Report*); A. M. Fitch – Andrews, Asa Fitch and his ancestry, *N. Y. Geneal. & Biogr. Rec.* 34(1903): 155-158.

[11] C. V. Riley, Dr. Asa Fitch, *Amer. Entomol.* 3(1880): 121-123.

[12] F. W. Goding, Three friends of New York agriculture, *Trans. N. Y. State Agric. Soc.* 50(1891): 358-366 (hereafter cited as Goding, Three friends).

[13] H. B. Weiss, *The Pioneer Century of American Entomology* (New Brunswick: published by the author, 1936), p. 173.

[14] R. M. Timm and R. E. Lee, Jr., Do bot flies, *Cuterebra* (Diptera: Cuterebridae), emasculate their hosts?, *J. Med. Entomol.* 18(1981): 333-336.

[15] A. Fitch, Entomology. No. XIV. - Insects imbedded in the interior of wood, *Country Gentleman* 9(1857): 201-202.

[16] Lintner, *First Annual Report*, p. 324.

[17] B. D. Walsh, Borers, *Prac. Entomol.* 1(1866): 25-31.

[18] Goding, Three friends.

[19] Lintner, *First Annual Report*, p. 325.

[20] D. L. Collins, the "Bug Catcher" of Salem, *Univ. State N. Y. Bull. Schools.* 40(1954): 193-196.

[21] Anon., Course of lectures at New Haven the ensuing winter, *J. N. Y. State Agric. Soc.* 10(1859): 62; Anon., Interesting lecture on insects, *Amer. Farmer*, series 5, 1(1860): 312-313; Anon., Insects injurious to fruit-trees, *Horticulturist & J. Rur. Art. & Rur. Taste* 15(1860): 342-343.

[22] B. P. Johnson, Annual report of the New York State Agricultural Society, *Trans. N. Y. State Agric. Soc.* 22(1863): 3-12; B. P. Johnson, Annual report of the New York State Agricultural Society, *Trans. N. Y. State Agric. Soc.* 24(1865): 3-10.

[23] E. H. Smith, The Comstocks and Cornell: in the people's service, *Ann. Rev. Entomol.* 21(1976): 1-25; A. Mallis, *American Entomologists* (New Brunswick: Rutgers University Press, 1971), pp. 126-138 (hereafter cited as Mallis, *Entomologists*).

[24] J. H. Comstock, Reminiscences, *J. Econ. Entomol.* 15(1922): 31-34.

[25] Mallis, *Entomologists*, pp. 126-138.

[26] B. D. Walsh, Popular remedies for noxious insects, *Prac. Entomol.* 1(1866): 71-74.

[27] *Ibid.*

[28] B. D. Walsh, Notices, *Prac. Entomol.* 2(1866): 35-36.

[29] T. W. Harris, *A Treatise on Some of the Insects of New England which are Injurious to Vegetation*, second edition (Boston, 1852), p. 1.

[30] A. Fitch, Address, on our most pernicious insects, *Trans. N. Y. State Agric. Soc.* 19(1860): 588-598.

[31] A. Fitch, Sixth report on the noxious and other insects of the State of New York, *Trans. N. Y. State Agric. Soc.* 20(1861): 745-868.

[32] A. Fitch, Report on the noxious, beneficial, and other insects of the State of New York, *Trans. N. Y. State Agric. Soc.* 14(1855): 705-880.

[33] A. Fitch, "Wheat midge," *J. N. Y. State Agric. Soc.* 8(1857): 67-68 (hereafter cited as Fitch, Wheat midge).

[34] E. P. Felt, Observations on the identity of the wheat midge, *J. Econ. Entomol.* 5(1912): 286-288.

[35] A. Fitch, Insects injurious to vegetation. - No. 3. The wheat-fly. *Amer. Q. J. Agric. & Sci.* 2(1845): 233-264.

[36] Fitch, Wheat midge.

[37] R. L. Doutt, The historical development of biological control, in *Biological Control of Insect Pests and Weeds*, P. DeBach, ed. (New York: Reinhold Publishing Corp., 1964), pp. 21-42 (hereafter cited as Doutt, Development of Biological Control).

[38] Fitch, Wheat midge.

[39] J. C. G. Kennedy, *Preliminary Report on the Eighth Census, 1860* (Washington, D. C.: U. S. Census Office, 1862), pp. 82-84.

[40] B. D. Walsh, Importing European parasites, *Prac. Entomol.* 2(1867): 54-55.

[41] *Ibid.*

[42] B. D. Walsh to R. F. of New Jersey, letter, *Prac. Entomol.* 1(1866): 101.

[43] B. D. Walsh, Imported insects, *Prac. Entomol.* 1(1866): 117-125.

[44] Doutt, Development of Biological Control.

[45] A. Fitch, Disappearance of the wheat midge, *Country Gentleman* 17(1861): 290.

[46] H. Fernald, *Applied Entomology* (New York: McGraw-Hill Book Co., Inc., 1926), p. 317; U. P. Hedrick, *A History of Agriculture in the State of New York* (Albany: New York State Agricultural Society, 1933), pp. 334-335 (hereafter cited as Hedrick, *History*).

[47] Anon., Insects injurious to fruit-trees, *Horticulturist & J. Rur. Arts & Rur. Taste* 15(1860): 342-343.

[48] Hedrick, *History*, p. 400; A. J. Downing, *The Fruits and Fruit Trees of America* (New York: Wiley and Putnam, 1847), p. 269.

[49] J. G. Wilson and J. Fiske, eds., *Appleton's Cyclopedia of American Biography*, volume 6 (New York: D. Appleton and Co., 1899), p. 77.

[50] Hedrick, *History*, p. 399.

[51] A. Fitch, Address of Asa Fitch M. D., Entomologist of the Society, on the curculio and black knot of plum trees, *Trans. N. Y. State Agric. Soc.* 19: 599-612.

[52] Hedrick, *History*, p. 398.

[53] G. Webster, On preventing the destruction of trees by caterpillars, *Mem. Board Agric. State N. Y.* 2(1823): 250-251.

[54] A. Fitch, Report on the noxious, beneficial and other insects of the State of New York. *Trans. N. Y. State Agric. Soc.* 15(1856): 409-559 (hereafter cited as Fitch, Second Report).

[55] A. Fitch, Apple tree pests. Schonherr's weevil, and the orchard moths, *J. N. Y. State Agric. Soc.* 4(1853): 36-39.

[56] B. D. Walsh, Driving nails into fruit trees, *Prac. Entomol.* 1(1866): 87-88.

[57] Fitch, Second Report, pp. 437-439.

[58] Anon., The "Hydropult," *Amer. Agric.* 19(1860): 236-237.

[59] A. Fitch, The entomologist. Number 25 – The quince tingis, *Country Gentleman* 17(1861): 114.

[60] American Hydropult Company, New way of attacking insects [advertisement], *Amer. Agric.* 20(1861): 123.

[61] A. Fitch, It's here! – The Colorado potato beetle, *Salem Press* 26 (9 July 1875): n.p.

[62] Asa Fitch Diary, 24 Aug. 1871, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University.

[63] R. D. Harley, *Artists' Pigments, c. 1600-1835* (New York: American Elsevier Publishing Co., Inc., 1970), pp. 76-77.

[64] V. G. Dethier, *Mans' Plague?: Insects and Agriculture* (Princeton, N. J.: The Darwin Press, Inc., 1976), p. 110; J. H. Perkins, *Insects, Experts, and the Insecticide Crisis* (New York: Plenum Press, 1982), p. 3.

[65] B. P. Johnson, Dr. Fitch's sixth report on the noxious and other insects of the State of New York, *Trans. N. Y. State Agric. Soc.* 19(1860): 587.

[66] B. D. Walsh and C. V. Riley, Salutatory. To the agriculturists and horticulturists of the United States, *Amer. Entomol.* 1(1868): 2.

CHAPTER TWELVE

The Later Years

During the later years of his appointment as Entomologist of the New York State Agricultural Society, Dr. Fitch's productivity as an author diminished considerably. His last few official reports were mere skeletons of earlier works. Words did not come easily, and writing was a burden.[1] Furthermore, in 1859, he had contracted pneumonia, which left his lungs impaired.[2] A decade later the infirmities of age began to appear. On the occasion of his sixtieth birthday he reviewed his personal condition:

> Though I sensibly feel several of the infirmities of age creeping upon me more & more as time advances, none of these infirmities are so considerable yet as to incapacitate me from jogging along in my accustomed routine. A stiffness, disabling me from bending down to draw on boots or shoes, is the most annoying of anything. . . . In Albany last week, I weighed myself – 199 lbs. at evening, 195 next morning. I supposed I should exceed 200, it being occasionally remarked to me that I am getting corpulent – a fact I am myself aware of. With the little exercise I take this winter, I have little hunger or relish for food, and seldom does anything taste agreeable – though I manage to eat a pretty full meal thrice per day – & at 11 or 12 at night, I eat a dozen or more crackers with a glass of bottled cider, sweetened – this being the most delicious of anything that ever reaches my palate; and this does taste most refreshing & truly delicious, but it makes me so drowsy & dull I can do nothing after it, but read and drop to sleep in my chair, till 1 or oftener 2 o'clock, when I lie down, and sleep soundly, in the morning waking at 7 or 8, & often finding myself so stiff it is painful to stir, for a time, until my joints get limbered.[3]

In August of 1870, C. V. Riley, P. R. Uhler, and J. A. Lintner visited Dr. Fitch at his home; 10 years later Riley described how they had found him. He had been ill for some time and was very much bowed down. The strong, tall man had become quite round-shouldered from the force of stooping in pursuit of his studies, while the constant use of the microscope had produced a noticeable contrast between his left and right eyes. Genial, enthusiastic, and unassuming, he made a favorable impression on his distinguished visitors.[4]

The State Agricultural Society was deteriorating at the same time. Secretary Johnson, the Society's leading spirit and a close, personal friend of Dr. Fitch, died in April of 1869. Dr. Fitch was convinced that the new corresponding secretary, Thomas L. Harison, was antagonistic to him and wanted to replace him with "a tool of his own – Lintner I presume. . . ."[5] Lintner also began to appear antagonistic to Dr. Fitch, who found in the budding entomologist indications of empiricism and charlatanry. Lintner once informed Dr. Fitch about some recently discovered parasites of a pest insect without going into details, apparently to deny him the honor of determining the name of the parasite species. "He is following in Hall's footsteps quite evidently – that made Hall so contemptible in the eyes of Emmons & others who came to know his paltry secretiveness in such matters."[6]

In fact, James Hall, Director of the New York State Museum of Natural History, wanted to have entomology designated an official department of the Museum, leaving Lintner, then a Zoological Assistant, free to pursue studies in this line.[7] Perhaps through Hall's efforts, Dr. Fitch's entomological position was abolished by the State Legislature effective October 1, 1872.[8] Although the law that abolished it was passed in May, Dr. Fitch knew nothing of it until November 1 when he went to the *Cultivator* office. There he received a check for $250, his quarter's salary, and he was told that the entomological appropriation was omitted from the bill last winter, thus ending his payments. He was surprised he had not known this earlier, although he had many indications of the indifference of Harison on this subject. He felt that it was anything but courteous to omit this item from the bill without telling him. Secretary Johnson had always promptly informed him when there had been any risk it would be struck from the bill so he could be on hand to argue for its retention.

It was evident that the Society, now under very different management, was rapidly degenerating. However, Dr. Fitch felt the appropriation had been continued much longer than originally expected and that he was getting too old to continue with the task. In fact, a feeling of great relief accompanied his release from it. All he wanted was an appropriation for having his reports revised and published in their entirety. He privately suspected that Hall figured actively in this affair and had obtained an appropriation for an entomologist and botanist for the State Cabinet in place of his entomological appropriation.[9]

In January of 1873, Dr. Fitch wrote to the Executive Committee of the State Agricultural Society, curtly requesting to be excused from serving further as Entomologist of the Society. He was so convinced the Society wanted to get rid of him that self-respect would not allow him to continue in its service.[10] In 1874, Lintner was placed in charge of the entomological work of the State Museum, and the collection of insects that Dr. Fitch made for the Agricultural Society was placed in his care.[11] In 1880, in accordance with a provision made by the State Legislature for replacing Dr. Fitch, Lintner was appointed entomologist by Governor Cornell.[12] In 1881, he was appointed State Entomologist and charged with studying insects injurious to agriculture and devising methods for their control. He was required to render an annual report of his investigations to the Legislature and to arrange for the State Museum a collection of insects taken in the course of his labor.[13] Finally, in 1883, Lintner, as State Entomologist, was made a member of the scientific staff of the State Museum.[14] He continued to serve in that capacity until his death in 1898.

About five months after Dr. Fitch retired, the State Legislature appropriated $1500 for the revision and completion of his reports for publication.[15] He completed the revision, and in 1875 it was presented to the Legislature. A resolution for printing 2000 copies under the direction of the Board of Regents of the University was passed by the Assembly, but it failed to receive concurrence from the Senate.[16] Two years later, Secretary Harison proposed to Joseph Henry that the Smithsonian Institution publish the revision, but apparently nothing resulted from that proposal.[17] By 1883, Lintner was unable to locate the manuscript.[18]

Dr. Fitch, now 66 years old, was becoming increasingly feeble. He passed his remaining years working on his insect collection, the history of Washington County, the Fitch family genealogy, and occasional civic and church affairs. They were in some respects sad and difficult years. He cared little about personal appearance and was plagued by financial woes and family misfortune. His daughter Sarah returned to Salem with two children and three stepchildren while her husband attempted to succeed as a southern cotton grower after the Civil War. Taking care of her and her family and putting his son Elias Pattison through law school hindered Dr. Fitch's ability to discharge the mortgage on his farm, which he wanted to leave unencumbered to his children and grandchildren.[19] His grandson Charles Horace died in 1875, and his beloved son Asa James, whom he had hoped might follow in his footsteps and advance the work in entomology, died in 1877.[20] To make matters worse, Elias Pattison had moved to the West, was not heard from after 1875, and was feared dead.[21]

Joseph Albert Lintner (New York State Museum file photograph).

After Chicago burned in 1871, Dr. Fitch decided to move his office further from the house, so that if the latter burned, the office and its contents might be saved.[22] He valued his cabinet of insects at $5000, his library of some 1500 volumes at $2000, and the sum of his personal property at $10,500.[23] In the office, amid the accumulated clutter of many years of hard work, he tried to put his collection and manuscript notes in order. However, even after retirement he remained a poor correspondent and was out of contact with the entomological community. C. V. Riley, who revered Dr. Fitch, asked to be allowed to put the veteran entomologist's name on the list of contributors to the *American Entomologist*, of which he was Junior Editor. His senior, B. D. Walsh, had died from injuries sustained in a freak train accident, and Riley was left to run the journal without assistance. Apparently, he never even received a reply from Dr. Fitch.[24]

The development of a federal entomological commission, however, rekindled Dr. Fitch's desire to serve the public, although he was 67 years old at the time of its formation. Riley had lobbied for a national commission to fight the scourges of the Rocky Mountain locust, and after the United States Entomological Commission was finally authorized in 1876, he was appointed Chairman; A. S. Packard, Jr. and Cyrus Thomas were appointed Secretary and Treasurer.[25] Dr. Fitch learned of this from an item in a newspaper that he read just after beginning preparations to apply to the Secretary of the Interior for an appointment on the Commission. He was greatly disconcerted and dejected by this news.[26]

For many years, Dr. Fitch had been accumulating information on the Fitch family genealogy. In retirement he devoted much of his time to compiling and arranging his records of the family in America and England.[27] It was a labor of love, and he felt that if his life, "now verging toward the climacteric of 'three score years and ten,'" should not be spared long enough to finish the undertaking, he might at least leave it sufficiently complete that another person could finish it.[28] From his vast knowledge of Washington County, Dr. Fitch contributed material for Crisfield Johnson's *History of Washington Co., New York,* which was published in 1878.[29] Of course, he was a valued member of his church, the United Presbyterian Church of Salem. In 1867, he had the honor of addressing the congregation on the occasion of the centennial anniversary of their "Old White Church." It was apparently a rousing address:

> I began, "Gentlemen & Ladies" my loud, clear voice, & deliberate manner, I was at once conscious was just right — "Sons & daughters of the Old White Church in Salem" — I was speaking easy, loud, & plain — distinctly heard by the most distant one in the audience — . . . . "I come before you in one short hour to relate the incidents of a hundred years" — I was aware the audience was listening with the most vivid attention, & were taking the deepest interest in what I uttered — Cole [Editor of the *Salem Press*] tells me, a man in the gallery close to him, got up, as I ascended the pulpit, muttering to himself "I can't stay any longer" — & pausing to hear the first words, — "I *must* hear that" he said, & sat down, for some 15 mts. when he sprang up, saying in an undertone "I must'nt stay any longer; I must go; it's too bad" and with the utmost reluctance evident in his manner, he tore himself away.[30]

United Presbyterian Church, Salem, New York.

In 1868, the congregation surreptitiously paid $30 on Dr. Fitch's behalf for a diploma of life membership in the American Bible Society, and in 1870 they paid $150 for a diploma certifying that he was made a Life Director of the Society.[31]

A severe cold spell besieged Salem in January of 1879, and Dr. Fitch noticed a sore throat and cold developing.[32] He began to feel slight stitches of pain in the lower part of his lungs and surmised they were caused by breathing cold air.[33] Chronic nosebleeds left him so weak and unsteady that on February 12 he was unable to attend a meeting of the Evergreen Cemetery Association, of which he had been President since 1863.[34] On March 6, he felt so feeble that he considered it unsafe to remain in his office alone through the night, not knowing what might happen to him. He decided to sleep on a bed in the house, something he rarely did.

On April 8, Dr. Fitch died at the age of 70 years. He was buried in Evergreen Cemetery, where a family monument bears on one side an inscription devoted to him:

Asa Fitch
Physician and Naturalist
Born Died
Feb. 24, 1809 April 8, 1879
Eminent among compatriots:
Fame had not the power to win
from him humbleness of spirit,
purity of soul, modesty of
demeanor, charity and love
for his fellow men.

The local community, as well as the entomological community at large, mourned his death. The *Troy Morning Whig* carried the following encomium:

> "He was quiet, gentle, and unobtrusive in all his ways. He never sought the applause of men, although he often deserved it, and has behind him the record of a life devoted to the study of the minuter works of creation – minuter, however, only to the outward seeming, for in their beautiful formations, this skilful, practiced student of nature saw the handiwork of God revealed in wondrous beauty."[35]

In the *Popular Science Monthly*, E. P. Thurston wrote, "His life was full of strong, pure manhood – full of such labor and study as few men have physical power to endure – full of the gentleness, the kindliness, and peace which come of well-living, and full of the honors which his labors had earned."[36]

In the *American Entomologist*, C. V. Riley, one of the new arbiters of American economic entomology, wrote:

> In the death of Dr. Asa Fitch, Economic Entomology in this country has lost its oldest and ablest votary, and as a follower in the paths he so worthily trod, we reverently pay brief tribute to the memory of one who spent the larger part of his life in the untiring and successful study of the insects injurious to agriculture and horticulture. While his earlier writings were contemporaneous with those of Harris, and his later ones with those of Walsh, he will, judged by the work he did, rank first among the fathers of applied entomology in America.[37]

According to some scholars, by the time of Dr. Fitch's death people were becoming less religious and more doubtful of the ability of individuals to improve themselves. Darwin's theory of evolution played an important role in the destruction of the Victorian world view and the preoccupation with the pursuit of rational order. People became anxious to embody their cultural values in institutions. Following a period of revolutionary developments in American agriculture, the Morril, Hatch, Adams, and Smith-Lever Acts of the 1860's to early 1900's established the agricultural teaching, research, and extension network and created the first considerable market for economic entomologists in the United States. Professional entomology in America came of age. By 1894, 42 states and territories had employed entomologists. The image of Dr. Asa Fitch was their standard.[38]

REFERENCE NOTES

[1] Asa Fitch Diary, 6 Dec. 1870, 29 Apr. 1871, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University (hereafter cited as Diary, followed by the date of the record).

[2] A. M. Fitch-Andrews, Asa Fitch and his ancestry, *N. Y. Geneal. & Biogr. Rec.* 34(1903): 155-158 (hereafter cited as Fitch-Andrews, Asa Fitch).

[3] Diary, 24 Feb. 1869.

[4] C. V. Riley, Dr. Asa Fitch, *Amer. Entomol.* 3(1880): 121-123 (hereafter cited as Riley, Dr. Fitch).

[5] Diary, 9 Feb. 1870, 6 Feb. 1871.

[6] *Ibid.*, 6 Oct. 1871.

[7] J. A. Lintner to S. H. Scudder, letter dated 24 Jan. 1872, New York State Museum.

[8] Laws of New York, Chapter 541. 1872.

[9] Diary, 1 Nov. 1872.

[10] *Ibid.*, 20 Jan. 1873.

[11] R. D. Glasgow and K. F. Chamberlain, Sketch of the entomological work of the State Museum and its antecedents, *N. Y. State Mus. Bull.* 313(1937): 96-101(hereafter cited as Glasgow and Chamberlain, Sketch); Executive Committee, Annual Meeting, 1874, *Trans. N. Y. State Agric.* Soc. 32(1878): 287-290.

[12] Laws of New York, Chapter 549, 1880; Glasgow and Chamberlain, Sketch.

[13] Laws of New York, Chapter 377, 1881; Glasgow and Chamberlain, Sketch.

[14] Laws of New York, Chapter 355, 1883; Glasgow and Chamberlain, Sketch.

[15] Laws of New York, Chapter 760, 1873.

[16] New York State Assembly Journal, 1875, pp. 864, 976, 1376.

[17] T. L. Harison to J. Henry, letter dated 14 Mar. 1877, Record Unit 26, Box 79, Volume 164 (Office of the Secretary, 1863-1979, Incoming Correspondence), Smithsonian Institution Archives.

[18] J. A. Lintner, *First Annual Report on the Injurious and Other Insects of the State of New York* (Albany, 1882), pp. 296-297.

[19] Diary, 25 Dec. 1865, 8 Dec. 1867, 21 May 1869, 24 Aug. 1869, 25 Apr. 1870, 10 July 1878; M. A. Marston, the lady of the diary, or the little Yankee goes South, undated, Manuscript Group 2086, Department of Manuscripts & University Archives, Cornell University Libraries; A. M. Fitch-Andrews, Genealogy, pp. 54-58, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University (hereafter cited as Fitch-Andrews, Genealogy).

[20] Diary, 17 Aug. 1865, 3 June 1875, 20 Nov. 1877; A. Fitch, A photostat copy of some Fitch genealogy notes, undated, New York State Library.

[21] Fitch-Andrews, Genealogy, p. 59.

[22] Diary, 16 Nov. 1869, 31 Oct. 1871.

[23] *Ibid.*, 2 July 1870.

[24] C. V. Riley to A. Fitch, letter dated 12 Dec. 1869, New York State Museum.

[25] A. Mallis, *American Entomologists* (New Brunswick, Rutgers University Press, 1971), p. 74.

[26] Diary, 30 Mar. 1877.

[27] Fitch-Andrews, Asa Fitch.

[28] A. Fitch, Fitch Family (circular), 1874, New York State Archives.

[29] Diary, 14 May 1878, 2 Aug. 1878.

[30] *Ibid.*, 27 Aug. 1867.

[31] *Ibid.*, 6 Oct. 1868, 29 Sept. 1870.

[32] *Ibid.*, 14 Jan. 1879.

[33] *Ibid.*, 17 Jan. 1879.

[34] *Ibid.*, 28 Jan. 1879, 20 Feb. 1879, 24 Feb. 1879; A. Fitch to Evergreen Cemetery Association, letter dated 12 Feb. 1879, Dr. Asa Fitch Historical Society, Salem, N. Y.; C. Johnson, *History of Washington Co., New York* (Philadelphia: Everts & Ensign, 1878), p. 187.

[35] Anon., Death of Asa Fitch, M. D., *Troy Morning Whig* 45(9 Apr. 1879): 2.

[36] E. P. Thurston, Sketch of Dr. Asa Fitch, *Pop. Sci. Monthly* 16(1879): 116-120.

[37] Riley, Dr. Fitch.

[38] J. K. Barnes, Insects in the new nation: a cultural context for the emergence of American entomology, *Bull. Entomol. Soc. Amer.* 31(1985): 21-30.

APPENDIX A

Entomological Publications by Dr. Asa Fitch

In the following list, bibliographic data are presented for 222 entomological research reports, popular articles, and other communications written by Dr. Fitch. Works that are full or partial reprints, compilations, revisions, or other forms of repetition are noted as such. Thorough annotations regarding many of Dr. Fitch's publications can be found in J. A. Lintner's *First Annual Report on the Injurious and Other Insects of the State of New York* (Albany, 1882, pp. 291-325).

All of Dr. Fitch's official reports on the noxious, beneficial, and other insects of New York State, except the twelfth, thirteenth, and fourteenth, were printed in more than one edition. The original editions, published in the *Transactions of the New York State Agricultural Society*, are generally scarce and have been since before the turn of the century. The failure of many subsequent scholars to cite the earliest edition has resulted in numerous inconsistencies and much confusion in citing Dr. Fitch's works. Also, many scholars who cited the first edition failed to give the correct publication date, perhaps because the *Transactions* for any one year were usually published a year or more later. Because his reports (except the eleventh) contain descriptions of new taxa, it is especially important that accurate bibliographic data be available. Lintner presented a bibliography of the Fitch reports in his *First Annual Report*, which is now also rare. More recently, Louise M. Russell gave a careful bibliography that is generally available (*Ann. Entomol. Soc. Amer.* 53 [1960]:326-327).

Even in these carefully compiled bibliographies, inaccurate data are preserved. Several issues of the *Transactions* bear inaccurate publication dates. The volume of *Transactions* for 1856, containing Dr. Fitch's third report, bears an 1856 publication date. However, in his report, Dr. Fitch refers to the year of authorship as 1857, and the *New York State Assembly Journal* indicates that the Senate and Assembly did not concur on a resolution to print the volume until April 14, 1857. The volume of *Transactions* for 1869, containing the thirteenth report, bears the date 1870, but Dr. Fitch's notes on species described in that volume indicate it was published in February of 1871. The volume for 1870, containing the fourteenth report, has two title pages. One bears the date 1871; the other, 1872. That volume contains a certified copy of the Society's constitution dated February 26, 1872. Dr. Fitch's notes also indicate that it was published in February of 1872.

1845a. An essay upon the wheat-fly, and some species allied to it. Albany. 32 pp.
(Reprint of 1845c.)

1845b. Insects injurious to vegetation. – No. 2. Insects of the genus *Cecidomyia*, including the Hessian fly and wheat fly. Amer. Q. J. Agric. & Sci. 1:255-269.

1845c. Insects injurious to vegetation. – No. 3. The wheat-fly. Amer. Q. J. Agric. & Sci. 2:233-264.

1846a. An essay upon the wheat-fly, and some species allied to it. Albany. 38 pp.
(From Trans. N. Y. St. Agric. Soc., *according to the* National Union Catalog of Pre-1956 Imprints; *presumably a reprint of 1846f; I have not seen a copy of this publication.)*

1846b. The Hessian fly. Amer. Farmer (4th Series) 2:179-183.
(Partial reprint of 1846d.)

1846c. The Hessian fly, its history, character, transformations, and habits. Albany. 63 pp.
(Compilation of 1846d and 1847e.)

1846d. Insects injurious to vegetation. – No. IV. The Hessian fly. Amer. Q. J. Agric. & Sci. 4:244-264, 257*-264*.

1846e. Letter from Dr. Fitch – respecting the essay on the wheat fly. Ohio Cultivator 2:51.

1846f. The wheat-fly. Trans. N. Y. State Agric. Soc. 5(1845):255-291.
(Revision of 1845c.)

1847a. The grain moth – *Tinea granella*. Cultivator (2nd Series) 4:13-14.

1847b. The Hessian fly. Amer. Farmer (4th Series) 2:200-205.
(Partial reprint of 1846d.)

1847c. The Hessian fly: its history, character, transformations, and habits. Albany. 60 pp.
(Reprint of 1847d.)

1847d. The Hessian fly: its history, character, transformations, and habits. Trans. N. Y. State Agric. Soc. 6(1846):316-373.
(Revision of 1846d and 1847e.)

1847e. Insects injurious to vegetation. – No. V. The Hessian fly. – (continued). Its characters, transformations, and habits. Amer. J. Agric. & Sci. 5:1-27.

1847f. List of noxious insects. Amer. J. Agric. & Sci. 6:145-152.

1847g. Winter insects of eastern New York. Amer. J. Agric. & Sci. 5:274-284.

1848a. The American currant moth, (*Abraxas? ribearia*). Albany. 11 pp.
(Reprint of 1848b.)

1848b. The currant-moth, *Abraxas? ribearia*. Trans. N. Y. State Agric. Soc. 7(1847):461-469.

1849a. Catalogue of the insects in the State Cabinet of Natural History, December 1, 1848, pp. 27-39. *In* Second annual report of the Regents of the University, on the condition of the State Cabinet of Natural History, with catalogues of the same. Made to the Senate January 12, 1849. Albany. 103 pp.

1849b. A historical, topographical and agricultural survey of the county of Washington. Part first. Trans. N. Y. State Agric. Soc. 8(1848):877-975.

1850. A historical, topographical and agricultural survey of the County of Washington. Part second – part fifth. Trans. N. Y. State Agric. Soc. 9(1849):753-944.

1851a. Catalogue with references and descriptions of the insects collected and arranged for the State Cabinet of Natural History, pp. 43-69. *In* Fourth annual report of the Regents of the University, on the condition of the State Cabinet of Natural History, and the historical and antiquarian collection, annexed thereto. Made to the Senate, January 14, 1851. Albany. 146 pp.
(The established publication date of this catalogue is February 28, 1851. See J. N. Y. Entomol. Soc. *92(1984):27-34.)*

1851b. Wheat insects – joint-worm. Cultivator (2nd Series) 8:321-324.

1852a. (untitled) J. N. Y. State Agric. Soc. 3:37.

1852b. Striped blistering fly. J. N. Y. State Agric. Soc. 3:55.

1853a. Apple tree pests. Schonherr's weevil and the orchard moth. Salem Press, July 12 (unpaged).

1853b. Apple tree pests. Schonherr's weevil, and the orchard moths. J. N. Y. State Agric. Soc. 4:36-39.
(Reprint of 1853a, with additional material.)

1854a. Apple tree pests. Schonherr's weevil and the orchard moth. Trans. N. Y. State Agric. Soc. 13(1853):178-187.
(Reprint of 1853b.)

1854b. Insect survey. J. N. Y. State Agric. Soc. 5:36-37.

1854c. Insects of Algiers, from the Museum of Natural History of Paris. Trans. N. Y. State Agric. Soc. 13(1853):369-379.

1854d. Plant-lice, drouth, etc. J. N. Y. State Agric. Soc. 5:37.

1855a. The chinch bug. Comments on the above by Dr. Fitch. Cultivator (3rd Series) 3:237-239.
(Reprint of 1855c.)

1855b. *Coccus arborum- linearis*, Geoff. Proc. Entomol. Soc. Lond. 3:77-78.

1855c. Entomology. The chinch bug. Comments on the above by Dr. A. Fitch. Country Gentleman 5:396.

1855d. Entomology. No. IV. – The apple plant louse. Country Gentleman 6:48.

1855e. Entomology – No. IV. The apple plant louse. Cultivator (3rd Series) 3:278-279.
(Reprint of 1855d.)

1855f. Entomology – No. V. Insects which destroy plant lice. Country Gentleman 6:158-159, 174-175.

1855g. Entomology. No. 6 – Gaylord's wheat-caterpillar. Country Gentleman 6:331.

1855h. Entomology. No. 7 – The wheat thrips and three-banded thrips. Country Gentleman 6:385-386.

1855i. First report on the noxious, beneficial and other insects, of the State of New-York. Made to the State Agricultural Society, pursuant to an appropriation for this purpose from the legislature of the state. Albany. 180 pp.
(Reprint of 1855n.)

1855j. The hunter weevil. Country Gentleman 5:373.

1855k. The hunter weevil. Cultivator (3rd Series) 3:221.
(Reprint of 1855j.)

1855l. Osage orange insect. Country Gentleman 5:38-39.

1855m. Plum tree caterpillars. Country Gentleman 5:234.

1855n. Report. Trans. N. Y. State Agric. Soc. 14(1854):705-880.
(This report is generally known as Fitch's First Report.)

1856a. Entomology. No. 6 – Gaylord's wheat-caterpillar. Cultivator (3rd Series) 4:19.
(Reprint of 1855g.)

1856b. Entomology. No. 8 – Cut-worms. Country Gentleman 7:154-155, 171.

1856c. Entomology. No. 8 – Cut-worms. Cultivator (3rd Series) 4:115-116.
(Reprint of 1856b.)

1856d. Entomology. No. IX. – The American vaporer moth. Country Gentleman 7:217-218, 235.

1856e. Entomology. No. IX. – The American vaporer moth. Cultivator (3rd Series) 4:154-156.
(Reprint of 1856d.)

1856f. Entomology. No. X. – Borer in apple trees – the *Buprestis*. Country Gentleman 8:27.

1856g. Entomology. No. X. – Borer in apple trees – the *Buprestis*. Cultivator (3rd Series) 4:240-241.
(Reprint of 1856f.)

1856h. Entomology. No. XII. – The rose-bug. Country Gentleman 8:75-76.

1856i. Entomology. No. XII. – The rose-bug. Cultivator (3rd Series) 4:270-271.
(Reprint of 1856h.)

1856j. First and second report on the noxious, beneficial and other insects, of the State of New-York. Made to the State Agricultural Society, pursuant to an appropriation for this purpose from the legislature of the state. Albany. 336 pp.
(Reprint of 1855n and 1856l.)

1856k. The joint worm in barley. J. N. Y. State Agric. Soc. 7:76.

1856l. Report on the noxious, beneficial and other insects of the State of New-York. Trans. N. Y. State Agric. Soc. 15(1855):409-559.
(This report is generally known as Fitch's Second Report.)

1857a. Cut-worms (*Viviparous*, S.). J. N. Y. State Agric. Soc. 8:22.

1857b. Entomology. Boston Cultivator, January 31.

1857c. Entomology. No. 13 – The prickly *Leptostylus* – a worm under the bark of apple trees. Country Gentleman 9:78.

1857d. Entomology. No. 13 – The prickly *Leptostylus* – a worm under the bark of apple trees. Cultivator (3rd Series) 5:77-78.
(Reprint of 1857c.)

1857e. Entomology. No. XIV. – Insects imbedded in the interior of wood. Country Gentleman 9:201-202.

1857f. Entomology. No. XIV. – Insects imbedded in the interior of wood. Cultivator (3rd Series) 5:138-139.
(Reprint of 1857e.)

1857g. Entomology. No. 15 – Grasshoppers. Answer to the above by Dr. Fitch. Country Gentleman 10:42-43.

1857h. Entomology. No. 15 – Grasshoppers. Cultivator (3rd Series) 5:245-246.
(Reprint of 1857g.)

1857i. Entomology. – No. 16. The hunter weevil in young corn. Beetles upon and worms in potato vines. Gooseberry insects. Country Gentleman 10:91.

1857j. Entomology – No. 16. The hunter weevil in young corn. Beetles upon, and worms in, potato vines. Gooseberry insects. Cultivator (3rd Series) 5:273.
(Reprint of 1857i.)

1857k. The may-beetle. Genesee Farmer (2nd Series) 18:239-241.

1857l. Slug worm. Country Gentleman 10:145.

[1857m.] Third report on the noxious and other insects of the State of New-York. Trans. N. Y. State Agric. Soc. 16(1856):315-490.
(The publication date printed in the Transactions, *1856, is apparently a misprint. In his report, Dr. Fitch refers to the year of authorship as 1857, and the* New York State Assembly Journal *indicates that the Assembly and Senate did not concur on a resolution to print the* Transactions *for 1856 until April 14, 1857.)*

1857n. Weevil in seeds from the Patent Office. J. N. Y. State Agric. Soc. 8:29.

1857o. Wheat midge. J. N. Y. State Agric. Soc. 8:67-68.

1858a. The entomologist. The fall web-worm – No. XVII. Country Gentleman 12:239.

1858b. Entomology – No. 16. Experiments – Soap on apple trees – Powdered charcoal on cucumber plants. Country Gentleman 12:15.

1858c. Entomology – No. 16. Experiments – soap on apple trees – powdered charcoal on cucumber plants. Cultivator (3rd Series) 6:238-239.
(Reprint of 1858b.)

1858d. The fall web-worm – No. XVII. Cultivator (3rd Series) 6:341-342.
(Reprint of 1858a.)

1858e. Fourth report on the noxious and other insects of the State of New-York. Trans. N. Y. State Agric. Soc. 17(1857):687-753.

1858f. Injurious insect on the oak. Country Gentleman 12:74.

1858g. Say's heteropterous Hemiptera. Trans. N. Y. State Agric. Soc. 17:754-814.

1858h. Wheat midge. Trans. N. Y. State Agric. Soc. 17 (1857):319-320.
(Reprint of 1857o.)

1859a. The entomologist. XVIII – The golden tortoise beetle. Country Gentleman 13:50.

1859b. Entomology. No. XIX. – Beetles infesting grapevines. Country Gentleman 14:171.

1859c. Entomology. No. XX. – The parasitic destroyer of the *Curculio*. Country Gentleman 14:221.

1859d. Fifth report on the noxious and other insects of the State of New York. Trans. N. Y. State Agric. Soc. 18(1858):781-854.

1859e. Maple leaf-cutter. Country Gentleman 14:225.

1859f. Maple leaf-cutter. Cultivator (3rd Series) 7:330-331.
(Reprint of 1859e.)

1859g. A new barley insect. Country Gentleman 13:250.
(Reprint of 1859i.)

1859h. A new barley insect. Cultivator (3rd Series) 7:148.
(Reprint of 1859i.)

1859i. A new barley insect. J. N. Y. State Agric. Soc. 9:114-115.

1859j. No. XX. – The parasitic destroyer of the *Curculio*. Cultivator (3rd Series) 7:340-341.
(Reprint of 1859c.)

1859k. Third, fourth, and fifth reports on the noxious, beneficial and other insects, of the State of New York. Made to the State Agricultural Society, pursuant to an appropriation for this purpose from the legislature of the state. Albany. 324 pp.
(Reprint of 1856m, 1858e, and 1859d.)

1859l. The thousand-legged worm. Answer to the above by Dr. Fitch. Country Gentleman 14:27.

1859m. The thousand-legged worm. Answer to the above by Dr. Fitch. Cultivator (3rd Series) 7:254.
(Reprint of 1859l.)

1860a. Address of Asa Fitch M. D., Entomologist of the Society, on the *Curculio* and black knot on plum trees. Pages 15-28 *in* The most pernicious species of United States insects, and the *Curculio*, two addresses delivered at the annual meetings of the New York State Agricultural Society, A. D. 1859 and 1860. By Asa Fitch, M. D., Entomologist of the Society. Albany. 28 pp.
(Reprint of 1860b.)

1860b. Address of Asa Fitch M. D., Entomologist of the Society, on the *Curculio* and black knot on plum trees. Trans. N. Y. State Agric. Soc. 19(1859):599-612.

1860c. Address, on our most pernicious insects, delivered at the annual meeting, February, 1859. Pages 3-13 *in* The most pernicious species of United States insects, and the *Curculio*, two addresses delivered at the annual meetings of the New York State Agricultural Society, A. D. 1859 and 1860. Albany. 28 pp.
(Reprint of 1860d.)

1860d. Address, on our most pernicious insects, delivered at the annual meeting, February, 1859. Trans. N. Y. State Agric. Soc. 19(1859):588-598.

1860e. The apple insect. Country Gentleman 16:32-33.

1860f. The apple insect. Cultivator (3rd Series) 8:260.
(Reprint of 1860e.)

1860g. Entomological department. No. XXI – Locust leafminers. Country Gentleman 15:82.

1860h. The entomologist. No. 22 – The seventeen year cicada. Country Gentleman 15:210.

1860i. The entomologist. – No. 23. – The striped flea-beetle. Country Gentleman 16:36.

1860j. The entomologist. No. 24. – The pear blight beetle. Country Gentleman 16:302-303.

1860k. The entomologist. No. 24. – The pear blight beetle. Cultivator (3rd Series) 8:371.
(Reprint of 1860j.)

1860l. Entomology. Country Gentleman 15:384.

1860m. No. 23. – The striped flea-beetle. Cultivator (3rd Series) 8:270.
(Reprint of 1860i.)

1860n. Ravages of insects on forest and fruit trees – remedy. Albany Express, July 2.

1860o. Ravages of insects on forest and fruit trees – remedy. J. N. Y. State Agric. Soc. 11:21-22.
(Reprint of 1860n, with additional material.)

1860p. Ravages of insects on forest and fruit trees – remedy. Trans. N. Y. State Agric. Soc. 19(1859):775-776.
(Reprint of 1860o.)

1860q. The wonders of insect life. Country Gentleman 15:146-147.
(Extracted from 1855n.)

1861a. (untitled). Country Gentleman 18:96.

1861b. (untitled). Cultivator (3rd Series) 9:290.
(Reprint of 1861a.)

1861c. The army worm and cut worm. J. N. Y. State Agric. Soc. 12:3.

1861d. The army worm and cut worm. Field Notes, July 13.
(Reprint of 1861c.)

1861e. The army-worm moth. Boston Cultivator 23:275.

1861f. The army-worm's parasite. Boston Cultivator 23:276.

1861g. The bean weevil. Trans. R. I. Soc. Encouragement Domestic Ind. 1860:62-64.

1861h. The black blistering fly. Country Gentleman 18:193.

1861i. The black blistering fly. Cultivator (3rd Series) 9:325. *(Reprint of 1861h.)*

1861j. The cut worm and corn grub killer. Country Gentleman 18:33. *(Reprint of 1861l.)*

1861k. The cut worm and corn grub killer. Cultivator (3rd Series) 9:259. *(Reprint of 1861l.)*

1861l. The cut worm and corn grub killer. J. N. Y. State Agric. Soc. 12:10.

1861m. Disappearance of the wheat-midge. Amer. Farmer 2:378-379.

1861n. The entomologist. The army worm and cut worm. Country Gentleman 18:18. *(Reprint of 1861c.)*

1861o. The entomologist. No. 25 – The quince *Tingis*. Country Gentleman 17:114.

1861p. The entomologist. No. 26 – The wheat midge. Country Gentleman 17:226.

1861q. The entomologist. No. 27 – Disappearance of the wheat midge. Country Gentleman 17:290.

1861r. The entomologist. No. 28 – Apple tree borer. Country Gentleman 17:370.

1861s. The entomologist. No. 29 – The army worm moth. Country Gentleman 18:66.

1861t. The entomologist. No. 30. – The grain *Aphis*. Country Gentleman 18:114.

1861u. The entomologist. Snapping beetle – blight on apple trees. Country Gentleman 18:130.

1861v. The grain *Aphis*. N. Y. Observer 39(2):336.

1861w. The hunter weevil. Country Gentleman 18:80.

1861x. The hunter weevil. Cultivator (3rd Series) 9:268. *(Reprint of 1861w.)*

1861y. An important caution. Country Gentleman 18:161.

1861z. An important caution. Cultivator (3rd Series) 9:303. *(Reprint of 1861y.)*

1861aa. The locust insect. Country Gentleman 18:161.

1861bb. The new insect in rye. Amer. Agric. 20:235-236.

1861cc. The new insect upon grain fields. J. N. Y. State Agric. Soc. 12:17-18.

1861dd. No. 26 – The wheat midge. Cultivator (3rd Series) 9:150-151. *(Reprint of 1861p.)*

1861ee. No. 27 – Disappearance of the wheat midge. Cultivator (3rd Series) 9:178. *(Reprint of 1861q.)*

1861ff. No. 28 – Apple tree borer. Cultivator (3rd Series) 9:209. *(Reprint of 1861r.)*

1861gg. No. 29 – The army worm moth. Cultivator (3rd Series) 9:278-279. *(Reprint of 1861s.)*

1861hh. Sixth report on the noxious and other insects of the State of New York. Trans. N. Y. State Agric. Soc. 20(1860):745-868.

1861ii. Snapping beetle – blight on apple trees. Cultivator (3rd Series) 9:294. *(Reprint of 1861u.)*

1861jj. Worm on grape vines. J. N. Y. State Agric. Soc. 11:39. *(Reprint of 1861kk.)*

1861kk. Worm on grape vines. Trans. N. Y. State Agric. Soc. 20(1860):342-343.

1862a. The buffalo tree-hopper the cause of scars on the twigs of fruit trees. Amer. Agric. 21:172-173.

1862b. The entomologist. Entomological events of the past year. Country Gentleman 19:124-125.

1862c. The entomologist. No. 31. – Insect tumors and wounds in raspberry stalks. Country Gentleman 19:335.

1862d. The entomologist. No. 31. – Insect tumors and wounds in raspberry stalks. Cultivator (3rd Series) 10:189. *(Reprint of 1862c.)*

1862e. The entomologist. No. 32 – The asparagus beetle. Country Gentleman 20:81-82.

1862f. The entomologist. No. 32 – The asparagus beetle. Cultivator (3rd Series) 10:274-275. *(Reprint of 1862e.)*

1862g. The entomologist. No. 33 – The maple *Psocus*. Country Gentleman 20:162.

1862h. The grain *Aphis*. Prairie Farmer 10:291-292.

1862i. Insects the past year. J. N. Y. State Agric. Soc. 12:72. *(Reprint of 1862b.)*

1862j. Insects the past year. Trans. N. Y. State Agric. Soc. 21(1861):27-31. *(Reprint of 1862b.)*

1862k. Seventh report on the noxious and other insects of

the State of New York. Trans. N. Y. State Agric. Soc. 21(1861):813-859.

1863a. Borers in the honey locust. J. N. Y. State Agric. Soc. 13:19.

1863b. Borers in the honey locust. Trans. N. Y. State Agric. Soc. 22(1862):117-118.

1863c. A brief account of the most important injurious insects of the United States. Albany. 29 pp.
(Reprint of 1863j.)

1863d. Club wheat – our views on it. Country Gentleman 22:33.

1863e. Eighth report on the noxious and other insects of the State of New York. Trans. N. Y. State Agric. Soc. 22(1862):657-691.

1863f. The entomologist. The may beetle. Worm on grapevines. Country Gentleman 21:399.

1863g. The entomologist. The onion fly. Country Gentleman 21:63.
(Extracted from 1863j.)

1863h. The grapevine beetle and rose bug. Country Gentleman 22:65.

1863i. The grapevine beetle and rose bug. Cultivator (3rd Series) 11:261.
(Reprint of 1863h.)

1863j. Insects. Illus. Ann. Register Rural Affairs 9:293-321.

1863k. Insects. – The grain *Aphis*, wheat midge, etc. Trans. N. Y. State Agric. Soc. 22(1862):32-38.

1863l. The may beetle. Cultivator (3rd Series) 11:245.

1863m. Worm on grapevines. Cultivator (3rd Series) 11:245.

1864a. *Aphis* on apple-tree buds. Cultivator (3rd Series) 12:211.
(Reprint of 1864c.)

1864b. A curious insect. Cultivator (3rd Series) 12:274.
(Reprint of 1864d.)

1864c. The entomologist. *Aphis* on apple-tree buds. Country Gentleman 23:351.

1864d. The entomologist. A curious insect. Country Gentleman 24:79.

1864e. The entomologist. No. 34. – The buffalo tree-hopper. Country Gentleman 23:386.

1864f. The entomologist. No. 35 – The Nebraska bee-killer. Country Gentleman 24:63.

1864g. The entomologist. Notes from Dr. Fitch. Country Gentleman 24:47.

1864h. The hunter weevil. Country Gentleman 23:384.

1864i. The hunter weevil. Cultivator (3rd Series) 12:228.
(Reprint of 1864h.)

1864j. No. 34. – The buffalo tree-hopper. Cultivator (3rd Series) 12:214-215.
(Reprint of 1864e.)

1864k. Notes from Dr. Fitch. Cultivator (3rd Series) 12:262.
(Reprint of 1864g.)

1865a. Address delivered before the annual meeting of the State Agricultural Society, Albany, February 8th, 1865. Trans. N. Y. State Agric. Soc. 24:111-116.

1865b. Ants enemies to cut-worms. J. N. Y. State Agric. Soc. 15:79-80.

1865c. Entomological correspondence. Cultivator (3rd Series) 13:316-317.
(Reprint of 1865d.)

1865d. The entomologist. Entomological correspondence. Country Gentleman 26:190-191.

1865e. The entomologist. No. 36 – The *Aphis* on hops. Country Gentleman 25:274.

1865f. The entomologist. Plant lice – The hop *Aphis*. Country Gentleman 26:82.

[1865g.] Ninth report on the noxious and other insects of the State of New York. Trans. N. Y. State Agric. Soc. 23(1863):778-823.
(The publication date printed in the Transactions *is 1864. In his manuscript notes and personal diary, Fitch gives the publication date of this report as February, 1865.)*

1865h. No. 36 – The *Aphis* on hops. Cultivator (3rd Series) 13:170-171.
(Reprint of 1865e.)

1865i. Plant lice – the hop *Aphis*. Cultivator (3rd Series) 13:271.
(Reprint of 1865f.)

1865j. Report of Dr. Fitch on the noxious and other insects, detrimental to agriculture, also an address, delivered before the New York State Agricultural Society. Albany. 56 pp.
(Reprint of 1865a and 1865g.)

1865k. Sixth, seventh, eighth and ninth reports on the noxious, beneficial and other insects of the State of New York. Made to the State Agricultural Society, pursuant to an annual appropriation for this purpose from the legislature of the state. Albany. 259 pp.
(Reprint of 1861hh, 1862k, 1863e, and 1865g.)

1865l. Tenth report on the noxious and other insects of the State of New York. Trans. N. Y. State Agric. Soc. 24(1864):433-461.

1866a. Ants enemies to cut-worms. Trans. N. Y. State Agric. Soc. 25(1865):133.
(Reprint of 1865b.)

1866b. The cotton worm. Cultivator & Country Gentleman 28:257.

1866c. Joint-worm in wheat on Long Island. Cultivator & Country Gentleman 28:49.

1866d. The naturalist. Insects which injure grain crops. — I. The wheat midge. Cultivator & Country Gentleman 28:306.
(Extracted from 1863j.)

1866e. The naturalist. Insects which injure grain crops — II. The hessian fly. Cultivator & Country Gentleman 28:354.
(Extracted from 1863j.)

1866f. The sumac gall- *Aphis*. J. N. Y. State Agric. Soc. 16:73.

1866g. The vineyard. Beetle on the grape. Cultivator & Country Gentleman 28:142.

1867a. Eleventh report on the noxious, beneficial and other insects of the State of New York. Trans. N. Y. State Agric. Soc. 26(1866):487-543.

1867b. The entomologist. Currant borers. Cultivator & Country Gentleman 29:386.

1867c. Garden insects. Illus. Ann. Register Rural Affairs 13:91-104.

1867d. Insects on the potato. Cultivator & Country Gentleman 30:193.

1867e. Tenth and eleventh reports on the noxious, beneficial and other insects of the State of New York. Made to the State Agricultural Society, pursuant to an annual appropriation for this purpose from the legislature of the state. Albany. 90 pp.
(Reprint of 1865l and 1867a.)

1868a. Garden insects. Illus. Ann. Register Rural Affairs 14:197-212.

1868b. Twelfth report on the noxious, beneficial and other insects of the State of New York. Trans. N. Y. State Agric. Soc. 27(1867):889-932.

1868c. The vineyard. Excrescences upon grape leaves. Cultivator & Country Gentleman 32:127.

1869a. The entomologist. A curious water insect. Cultivator & Country Gentleman 33:154.

1869b. The entomologist. The garden millepedes. Cultivator & Country Gentleman 34:381, 402, 421-422.

1869c. The entomologist, grain *Aphis* in eastern Tennessee. Cultivator & Country Gentleman 34:35.

[1871.] Thirteenth report on the noxious, beneficial and other insects of the State of New York. Trans. N. Y. State Agric. Soc. 29(1869):495-566.
(The publication date printed in the Transactions *is 1870. In his manuscript notes, Fitch gives the publication date of this report as February, 1871.)*

[1872a.] Fourteenth report on the noxious, beneficial and other insects of the State of New York. Trans. N. Y. State Agric. Soc. 30(1870):355-381.
(The publication date printed in the Transactions *is 1871. In his manuscript notes and personal diary, Fitch gives the publication date of this report as February, 1872.)*

1872b. The naturalist. The Somerville shower of worms. Cultivator & Country Gentleman 37:251.

1873. The tortoise-beetle. Glens Falls Republican, July 22.

1875a. It's here — the Colorado potato beetle. Salem Press, July 9 (unpaged).

1875b. Noch einmal der Coloradokäfer. Entomol. Nachr., Patbus 1:141-142, 149-150.
(Extracted from 1865g and translated.)

1875c. Paris green. Salem Press, July 23 (unpaged).

1878. Ravages of insects on forest and fruit trees — remedy. Cultivator & Country Gentleman 43:471.
(Reprint of 1860o.)

1885. Winter insects of eastern New York, Pages 235-244 *in* Lintner, J. A. Second report on the injurious and other insects of the State of New York. Albany. 265 pp.
(Reprint of 1847g.)

1893. Catalogue with references and descriptions of the insects collected and arranged for the State Cabinet of Natural History. Rep. N. Y. State Mus. Nat. Hist. 46:383-413.
(Reprint of 1851a, with corrections.)

APPENDIX B

The Taxonomic Work, Collections, and Types of Dr. Asa Fitch

While researching the injurious insects of New York State, one of Dr. Fitch's first tasks was to identify the species with which he worked. So few American arthropods had been described that he frequently found it necessary to name, describe, and classify interesting species himself. He proposed 13 new generic names and 451 new specific and subspecific names in published works from 1845 to 1872. The names were proposed for various arthropods in 3 classes, 15 orders, and 107 families. Overall, about half of these names are valid. Dr. Fitch made greatest advances with the Homoptera; he proposed 179 nominal species and subspecies, with about 68 percent now considered valid. His worst record seems to have been with the Coleoptera; only 5 of his 43 species and subspecies names (12 percent) are considered valid. In fact, it seems that Dr. Fitch's insect collection contained many misidentified Coleoptera because he was unable to enlist the aid of specialists in this order. He apparently wrote to Dr. LeConte and other coleopterists repeatedly, asking for assistance, but none was forthcoming.[1]

Dr. Fitch was conservative about describing new taxa. It was difficult for him to know with certainty if a particular species or subspecies had already been named, described, and classified. His isolation in a rural district hindered his ability to obtain copies of publications from libraries, and pecuniary means did not allow him to import European works extensively. He also found it difficult to obtain many American entomological publications, including those of Thomas Say, one of which he eventually had reprinted.[2] He frequently had to borrow books from correspondents, and he laboriously copied them by hand. Dr. Fitch was less conservative, however, about naming and describing new varieties, and today these must be considered as proposals of new subspecies.[3]

Dr. Fitch clarified his concepts of genera, species, and varieties in a letter to Dr. T. W. Harris in 1852. He said that without the definite criterion of reproduction he would not know what a species is. Without this criterion, workers would continue to split species and create new names as long as they could detect minute differences that could be described or illustrated. To him, species were not merely artificial distinctions; they were natural entities. "What God hath joined together, let not man put asunder." Furthermore, he felt that there were natural genera and family groups, but that a large portion of them were purely artificial – divisions instituted for convenience and to aid the memory. He felt that genera should not be divided merely for convenience no matter how numerous the species, unless some good character could be found – a character clearly perceived in each of the species.[4]

Most of the arthropods that Dr. Fitch described were of agricultural importance in New York State. Thirty-one of his species are still deemed of such significance that they are listed in the 1982 issue of *Common Names of Insects and Related Organisms*.[5] Many specimens that he described and deposited in his personal collection came from near his home in Salem, New York, but he also had extensive material from elsewhere in North America and, in fact, nearly every corner of the globe. His specimen registers record data for nearly 36,000 specimens from New York State, 13,000 from elsewhere in North America, and several thousand from elsewhere in the world.

Dr. Fitch felt that an insect collection limited by political boundaries would produce a curtailed and imperfect science. ". . . With ships sailing from our principal port to all parts of the world – with our missionaries located in every heathen land – we should be inexcusable for not availing ourselves of these facilities for accumulating samples of the productions of other countries."[6] His collection contained many specimens from China sent by Reverend M. S. Culbertson of the Presbyterian Board of Foreign Missions. It also contained specimens from many parts of the world obtained by exchange with entomologists such as Sichel, Signoret, Fairmaire, Murray, and others. There were thousands of specimens from "Tullehassie, West of Arkansas" (=Tullahassee, Wagoner County, Oklahoma) sent by Dr. Fitch's esteemed friend, William Schenck Robertson, a pioneer educator at the Tullahassee Mission in Indian Territory. Dr. Fitch also received many specimens from his daughter Sarah, who moved to Mississippi in 1851 to teach. Occasional specimens were sent from various parts of the Union by such naturalists as T. W. Harris, P. R. Uhler, C. V. Riley, and others.[7]

The New York State Agricultural Society published a notice on Dr. Fitch's collection a few weeks after he was appointed the Society's entomologist:

> Dr. Fitch has already the most extensive private Collection of Insects in this country, we presume, and in some departments he has a larger number of species than are to be found in the British Museum. He has lately received from the President of the Entomological Society of France, and some of the members, a magnificent collection of several thousand specimens, embracing all their duplicate species from all parts of the world, containing one or more species in every important genus in the Science. . . . This is most valuable to the Dr., as it will enable him to arrange our New-York Insects without danger of falling into any important error.[8]

On August 23, 1870, C. V. Riley, State Entomologist of Missouri, P. R. Uhler of Baltimore, and J. A. Lintner, then zoological assistant at the New York State Museum of Natural History, successor to the State Cabinet of Natural History, visited Dr. Fitch in Salem and inspected his insect collection. Riley found a rich and valuable collection surpassing anything to be found in the West, including B. D. Walsh's collection.[9] He reported on the condition of the collection.

> At the time of our visit we found a large part of it in poor condition, principally on account of mold which had resulted from the moisture in his "office" and the use of the French "*cartons liégés*" [*sic*] which do not keep out the moisture so well as wooden boxes; but we are glad to learn from those who have lately examined it that, as a whole, the collection is yet in a state of good preservation. It is valuable not only because it contains the types of the insects described by Fitch, but because of the notes which accompany the specimens. Each specimen has a number referring to those notes, which fill 148 books and amount to about fifty-five thousand.[10]

Shortly after Dr. Fitch died, his daughter Abbie sought the assistance of P. R. Uhler with the family's attempt to dispose of the insect collection and library. The family wished to profit from a sale so they could use the money to retain the ancestral acres at Fitch's Point in Salem. Uhler recommended that the State of New York purchase the collection, but the family was still bitter about the way the State had treated Dr. Fitch in the last year of his public service and did not want it to become the owner. The family contacted several institutions that had entomology departments, but no purchaser was found.[11]

Francis G. Sanborn, a consulting naturalist from Andover, Massachusetts, was invited to visit Salem to appraise the insect collection. Widely known in the eastern United States for his care in the preparation of collections of insects and other objects of natural history, he had been hired to prepare the United States Department of Agriculture's entomological exhibit for the Centennial Exposition in Philadelphia in 1876.[12] In his account of Dr. Fitch's collection, which he described as a "monument of patient industry, unrivalled on this continent at least," he reported that the general collection filled 106 boxes (26 x 19. 5 cm) and comprised upwards of 55,000 specimens, nearly all of them in excellent condition. He also found two large cases containing about 120,000 duplicates (mostly Coleoptera), several boxes and trunks containing about 2000 specimens received on exchange, several boxes of galls and other insect productions, a large and valuable entomology library, an extensive manuscript catalog, and a microscope by Nachét.[13]

At the present time, it is not clear exactly how Dr. Fitch's personal insect collection was broken up and dispersed. Parts of the collection were apparently sold to various collectors. The Coccidae and some other Homoptera, along with pertinent notes from the manuscript catalog, were sold to the United States Department of Agriculture. Apparently, part of the collection and some notes were purchased from a dealer in second-hand books and insects in Philadelphia.[14] At one time, the catalog was in the possession of C. V. Riley and the Boston Society of Natural History.[15] The three collection registers that are deposited in the New York State Museum bear Boston Society of Natural History bookplates that are labelled, "From S. H. Scudder, Received Mch. 24, 1893." Over these labels is inscribed, "Presented to the N. Y. State Museum by the Boston Society of Natural History, May 4, 1933, M. B. Cobb, Librarian."

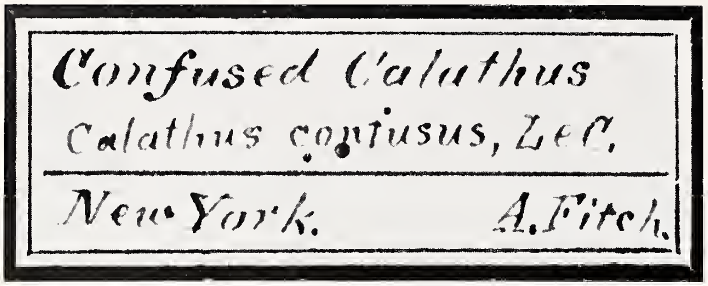
After being appointed Entomologist of the State Agricultural Society in 1854, Dr. Fitch contributed few, if any, insects to the State Cabinet of Natural History.[16] Instead, he immediately began to acquire material for the Agricultural Society's museum. The Society was interested in establishing a museum of practical entomology, displaying injurious insects and the damage they cause. To their knowledge, this was the first public museum established in the United States to accomplish this work, and the agriculturists and naturalists of Europe quickly took note.[17] At home, farmers and other citizens were interested in the progress being made with the museum, which displayed costumes and fabrics from foreign nations, antiquities and relics from this country, old spinning wheels and looms, grains

Agricultural Rooms, State Geological and Agricultural Hall, Albany, New York (From P.A. Chadbourne & W.B. Moore [eds.], The Public Service of the State of New York, *vol.III [1882]).*

and seeds from around the world, common and uncommon garden vegetables, farm implements from America and abroad, pressed plants, and many other items in addition to injurious insects. On May 19, 1860, the *New York Weekly Tribune* ran a lengthy description of the museum in which the insect collection was thoroughly explored.

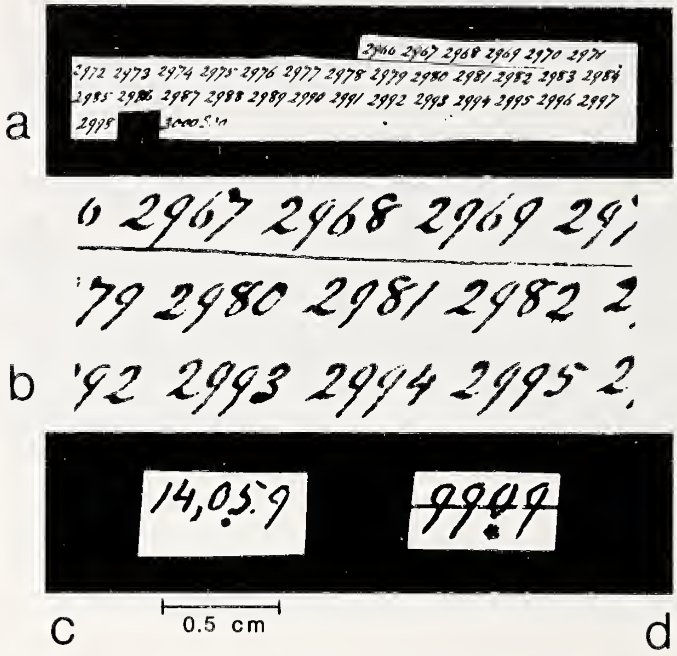
> The cases along one entire side of the third floor are appropriated to Dr. Asa Fitch's entomological collections, which already are superior to any others in the world in many respects. Time will be when the zealous student of Natural History will be able to study the nature and habits of our noxious and other insects more satisfactorily on this third floor of the State Society's Museum than he could anywhere else, and time will also be when our farmers will awake to the fact that one of their greatest benefactors has lived out his quiet life, and perhaps laid him down to die in an obscure rural district, with no monument to keep green his memory except these splendid collections which he freely gave years of his life to gather from our fields and forests.
>
> The Fitch collections, when arranged this Fall, will be divided so that the various insects in all their stages – egg, larva, pupa, and moth – will be placed in drawers beneath the cases, while the more roomy space of the latter will be devoted to the display of specimens which illustrate the ravages of the insects. There are now but few specimens set up in the cases, but quite enough to show the ultimate value of the collection. Thus we have a piece of basswood the substance of which has been mined out by white ants. Alongside it is a glass-covered box which contains specimens of our dread foe the wheat-midge, its larva, a male fly, and kernels of wheat shrunken and ruined. Another of these little boxes shows us the Hessian-fly, its larva, its flax-seed-like eggs, and a wheat straw broken open to show the "flax seeds" within. Here we have a twig of mountain-ash covered with scale insects; here, a twig of poplar, the eggs of the "executioner tree bug," strung along in two unbroken parallel and contiguous lines, like a string of little sandal-wood beads or a daintily-braided strand of maiden's hair; here we have a limb of black-oak cut off by the oak-pruner; here a piece of red cedar – which every one has believed insect proof – utterly destroyed by the stump wasp; while, like the mysterious foot prints in the red sand-stone and chalk, on the bit of pine bark, are to be seen the finger-like tracks of the "pine bark-beetle," starting from a central pit, or hole, and spreading – always four at one side and two at the other – like the fingers of a hand. In a bottle of spirits here we have the larvae of the "hickory moth," the largest known, which is so frightfully ugly – what with its long horns and bamboo-like joints – that we cannot blame the plantation darkies for calling it the "horned devil." Here is a hickory ax-helve, sound as a mit when first made, but since then completely riddled at one end by some hickory beetle, probably (says the label) by the *apate basillaris* – which of course will be perfectly intelligible to every one of our readers. In this case, near the stairway, we see a great section of apple wood – five feet in circumference, one foot ten in diameter – which has been literally honey combed by the borer. Not to occupy space with further enumerations, we will merely say that by this time next year farmers passing through Albany will be able to examine in the collection several thousand specimens of insects and their ravages.[18]

Dr. Fitch worked from time to time over the years to complete the collection of injurious insects of New York. He sometimes drew specimens from his personal collection, but he preferred to have fresh specimens, which were less moldy. In August of 1871 he made a major effort to complete the collection. He worked daytime cleaning specimens, checking identifications, and placing the insects in the cases. In the evenings, he printed labels. On October 7, he finished the collection and was free to draw the last of his annual salary. Altogether, he contributed 1504 specimens to the museum. Unfortunately, as he worked, dermestid beetles attacked the specimens, and watch crystals full of camphor failed to repel the pests.[19] In 1888, the New York State Legislature recognized the value of the collection and appropriated funds for its preservation.[20] A small part of that collection still exists, at the New York State Museum.



Confused Calathus
Calathus confusus, LeC.
New York. A.Fitch.

A printed label from an insect specimen prepared by Dr. Fitch for the New York State Agricultural Society's museum.



Typical labels from Dr. Fitch's personal insect collection: a) *uncut strip of labels;* b) *close-up view of a section of* a; c) *New York insect label 14,059, black ink on white paper;* d) *New York insect label *9909, black ink on white paper, crossed with one red line. Labels* c) *and* d) *same scale.*

Catalog of Taxonomic Names and Type Specimens

In the following catalog, all available arthropod names Dr. Fitch proposed in print are listed. Species and subspecies names are given in their original combinations with generic names; original spellings are preserved, even when incorrect. The names are arranged alphabetically by species or subspecies within each family. Families are arranged by phylogenetic classification. Variety names consisting of a single letter are not available and, therefore, not listed.[21] In all other cases, names proposed as varieties are treated as subspecies.[22] After each name, the date on which it was first proposed is given, followed by one or two letters corresponding with the appropriate publications listed in Appendix A and the page number on which it first appeared.

A name recognized as a valid recent combination, senior synonym, replacement name, or corrected spelling for a name proposed by Dr. Fitch is listed on the second line of each entry. In most cases these names were located in modern catalogs and revisions.

Dr. Fitch never designated a type specimen. Data concerning the type series (the specimens on which Dr. Fitch based the species or subspecies) are listed under "Original Specimens." The closest available approximation to a type series for a species or subspecies name proposed by Dr. Fitch consists of those specimens that can be proven, through a perusal of his registers and catalog, to have been in his collection before or during the year in which the name was made available. Specimens that Dr. Fitch considered variants or aberrants are not listed because they are not part of the type series.[23]

Dr. Fitch labelled nearly all of his specimens with individual numbers, recording them in four registers, along with collecting dates, localities, and other pertinent information. Label numbers written in black ink on white paper are recorded in one register of specimens collected in New York State. Label numbers written in black ink on white paper and crossed with one or two red lines are recorded in a second register of specimens from New York State. One red line designates that the label number is less than 10,000, and two red lines designates a number to which 10,000 should be added. Label numbers written in red ink on white paper are listed in a third register, which records specimens from elsewhere in North America. These three registers are deposited in the New York State Museum. In the following catalog, label numbers that are preceded by one or two asterisks correspond with specimen labels that are crossed with one or two red lines, respectively. A fourth register, deposited in the Museum of Science, successor to the Boston Society of Natural History, lists specimens from elsewhere in the world. The corresponding labels are written in black ink on colored papers.

In his manuscript catalog, Dr. Fitch kept sheets of notes (10 x 15 cm) on every arthropod species of which he was aware. On them he recorded brief diagnoses of the species followed by fuller descriptions and remarks. If he had a specimen of any given species, he recorded its number along with collection data on the appropriate sheet. Numbers underscored once or twice correspond with label numbers for New York specimens that were crossed with one or two red lines, respectively. Numbers that are overscored correspond with label numbers for specimens from outside New York State that exceed 10,000. Some of the notes include unpublished illustrations. Most of the catalog is deposited in the New York State Museum, but the sections on Psyllidae and Coccidae are in the Smithsonian Institution Archives, the section on Aphididae is with the United States National Museum aphid collection in Beltsville, and the Section on Collembola is in the library of the Museum of Science in Boston.

In his Homptera catalog (1851a), Dr. Fitch described 6 new genera, 85 new species, and 5 subspecies. Specimens of many taxa described in that publication are now in the New York State Museum, although the Psyllidae, many of the Aphididae, and a few specimens from other families were destroyed by museum pests. The specimens were taken from his personal collection and renumbered. They bear printed labels with numbers ranging from 609 to 874, which correspond with specimen numbers given in his published catalog but bear no relation to his manuscript catalog or specimen registers.[24]

Specimens that are or might be part of an original type series are listed in this catalog under "Extant Specimens." These include specimens that bear printed labels corresponding with the specimen numbers given in the Homoptera catalog (1851a), specimens with labels written by Dr. Fitch that can be shown to have been in his collection on or before the year in which he proposed the specific or subspecific name for them in print, and specimens without Fitch labels, but bearing labels written by subsequent workers that indicate them to be Fitch types. A slash (/) separates material taken from different labels on a given specimen. Extant specimens have been found in the New York State Museum (NYSM), the United States National Museum, including the Homoptera Collection and the National Parasite Collection at the Beltsville Agricultural Research Center (USNM), the main collection of the Museum of Comparative Zoology at Harvard University (MCZ), the T. W. Harris Collection at the MCZ (MCZH), and the Museum National d'Histoire Naturelle in Paris (MNHN). It is, of course, possible that specimens are present in other collections that have not been investigated.

For many species and subspecies, lectotypes should be designated from the lists of extant specimens, if designations have not been made already. W. D. Funkhouser designated lectotypes for the Membracidae described in the Homoptera catalog.[25] Keirans and Barnes designated lectotypes for the ticks described by Fitch.[26]

Please note that data are presented in this catalog just as they were found in the Fitch notes or on specimen labels. A listing for specimens from Tullehassie, AR, must be interpreted to mean that the specimens came from Tullahassee, OK.

Generic Names Proposed by Dr. Fitch

Order HEMIPTERA

Family MEMBRACIDAE

1. **Carynota** Fitch, 1851a:48.
   Carynota Fitch.
   Type-species:*Membracis mera* Say, by subsequent designation.
2. **Cyrtoisa** Fitch, 1851a:49.
   Cyrtolobus Goding (replacement name for *Cyrtosia* Fitch (correct spelling for *Cyrtoisa* Fitch), preoccupied by *Cyrtosia* Perris).
   Type-species:*Cyrtosia fenestrata* Fitch, by subsequent designation.
3. **Telamona** Fitch, 1851a:50.
   Telamona Fitch.
   Type-species:*Membracis ampelopsidis* Harris, by subsequent designation.

Family CICADELLIDAE

4. **Empoa** Fitch, 1851a:63.
   Empoa Fitch.
   Type-species:*Empoa querci* Fitch, by subsequent designation.
5. **Erythroneura** Fitch, 1851a:62.
   Erythroneura Fitch.
   Type-species:*Erythroneura tricincta* Fitch, by subsequent designation.
6. **Helochara** Fitch, 1851a:56.
   Helochara Fitch.
   Type-species:*Helochara communis* Fitch, by monotypy.

Family ISSIDAE

7. **Naso** Fitch, 1857m:396.
   Fitchiella Van Duzee (replacement name for *Naso* Fitch, preoccupied by *Naso* Lacépède).
   Type-species:*Naso robertsonii* Fitch, by monotypy.

Order NEUROPTERA

Family CONIOPTERYGIDAE

8. **Aleuronia** Fitch, 1855n:801.
   Malacomyza Wesmael.
   Type-species:*Aleuronia westwoodii* Fitch, by monotypy.

Family HEMEROBIIDAE

9. **Meleoma** Fitch, 1855n:786.
   Meleoma Fitch.
   Type-species:*Meleoma signoretii*, by monotypy.

Order LEPIDOPTERA

Family NOTODONTIDAE

10. **Eumetopona** Fitch, 1856l:467.
    Datana Walker.
    Type-species:*Phalaena ministra* Drury, by monotypy.

Family LASIOCAMPIDAE

11. **Planosa** Fitch, 1856l:494.
    Tolype Hübner.
    Type-species:*Planosa laricis* Fitch, by subsequent designation.

Order HYMENOPTERA

Family CYNIPIDAE

12. **Biarhiza** Fitch, 1859d:781.
    Biorhiza Westwood.
    Note: *Biarhiza* Fitch is an unjustified emendation of *Biorhiza* Westwood.
13. **Philonix** Fitch, 1859d:783.
    Philonix Fitch.
    Type-species:*Philonix fulvicollis* Fitch, by subsequent designation.

Specific and Subspecific Names Proposed by Dr. Fitch

Class CRUSTACEA

Order ISOPODA

Family ONISCIDAE

1. **Porcellio glaber confluentus** Fitch, 1855n:823.
Cylisticus convexus (Degeer).

2. **Porcellio limatus** *dorsalis* Fitch, 1855n:825.
Oniscus asellus Linnaeus.

3. **Porcellio glaber** Fitch, 1855n:823.
Cylisticus convexus (Degeer).
Original Specimens:13,986-987, Salem, NY, 12. xi. 1853, under a board at the east end of the woodshed.

4. **Porcellio immaculatus** Fitch, 1855n:824.
Porcellionides pruinosus (Brandt).
Original Specimens:2860, Tullehassie, AR, 1851, from Wm. S. Robertson, young; 5988, Tullehassie, AR, 1852, from Wm. S. Robertson; 8597-99, Mercer Co., IL, 6. x. 1854, dry bed of Duck Creek; Salem, NY, i. vi. 1855, under sticks and boards in the yard.

5. **Porcellio limatus lateralis** Fitch, 1855n:825.
Oniscus asellus Linnaeus.

6. **Porcellio limatus** Fitch, 1855n:824.
Oniscus asellus Linnaeus.
Original Specimens:13,984-985, Salem, NY, 12. xi. 1853, under wood in the wood yard.

7. **Porcellio limatus limbalis** Fitch, 1855n:825.
Oniscus asellus Linneaus.

8. **Porcellio limatus marginatus** Fitch, 1855n:825.
Oniscus asellus Linnaeus.

9. **Porcellio mixtus** Fitch, 1855n:824.
Porcellio spinicornis Say.
Original Specimens:Salem, NY, 6. xi. 1853, under logs in chip yard, one specimen; Salem, NY, 30. v. 1855, under logs back of woodshed, three specimens.

10. **Porcellio limatus multiguttatus** Fitch, 1855n:825.
Oniscus asellus Linnaeus.

11. **Porcellio mixtus variegatus** Fitch, 1855n:824.
Porcellio spinicornis Say.

12. **Porcellio vittatus** Fitch, 1855n:824.
Tracheoniscus rathkei (Brandt).
Original Specimens:6342-43, Stillwater, NY, 4. iv. 1836, under side of damp cellar door; 911-912, 15. ix. 1836, near Jesse Seymour's; 1132, Stillwater, NY, 14. iv. 1837, under stones north of Hodgman's woods; Salem, NY, 6-7. xi. 1853, numerous specimens taken under boards and logs about the woodshed; Salem, NY, 30. v. 1855, about the roots of peach trees, in front yard.

Class INSECTA

Order COLLEMBOLA

Family PODURIDAE

13. **Podura nivicola** Fitch, 1847g:283.
Hypogastrura nivicola (Fitch).
Original Specimens:12,223-227, Salem, NY, 5. i. 1847, on snow and in rivulets, Jarvis Martin's woods; 12,228-230, Salem, NY, 7. i. 1847, on pools in Mrs. Fitch's woods.

Family SMINTHURIDAE

14. **Symnthurus hortensis apicalis** Fitch, 1863e:671.
Bourletiella hortensis (Fitch).

15. **Symnthurus arvalis** Fitch, 1863e:673.
Bourletiella arvalis (Fitch).
Original Specimens:Salem, NY, 24. v. 1854, on a leaf of a young apple tree; 26. vi. 1862, in myriads on clover.

16. **Symnthurus hortensis basalis** Fitch, 1863e:671.
Bourletiella hortensis (Fitch).

17. **Symnthurus hortensis dorsalis** Fitch, 1863e:671.
Bourletiella hortensis (Fitch).

18. **Symnthurus elegans** Fitch, 1863e:674.
Sminthurinus elegans (Fitch).
Original Specimens:3795, 6. v. 1852, four specimens and numerous others found in a jar of diseased wheat straw from Virginia, sent to me by Dr. Harris. Possibly they may have come from the New York dirt put into the jar, and not from the Virginia straw.

19. **Symnthurus hortensis** Fitch 1863e:668.
Bourletiella hortensis (Fitch).
Original Specimens:12,341, Salem, NY, 3. vi. 1847, Jarvis Martin's wheat field; Salem, NY. 24. v. 1854, on apple trees, beat from the leaves; Salem, NY, 15-25. v. 1861, abundant on young wheat and rye; 26. vi. 1862, common on clover.

20. **Symnthurus hortensis juvenilis** Fitch, 1863e:671.
Bourletiella hortensis (Fitch).

21. **Symnthurus hortensis maturus** Fitch, 1863e:671.
Bourletiella hortensis (Fitch).

22. **Symnthurus novaeboracensis** Fitch, 1863e:674.
? *Dicyrtoma* sp.
Original Specimens:Salem, NY, 11. xi. 1853, found several specimens under a board, at the bars, west base of Battle Hill.

23. **Symnthurus signifer** Fitch, 1863e:675.
Original Specimens:3793, four specimens, found in a jar of diseased wheat straw from Virginia, sent me by Dr. Harris. They may possibly have come from the damp dirt put into the jar, and not from the straw.

Order PLECOPTERA

Family TAENIOPTERYGIDAE

24. **Nemoura nivalis** Fitch, 1847g:279.
Taeniopteryx nivalis (Fitch).
Original Specimens:5107, Fort Miller, NY, 1832; 1538, Stillwater, NY, 4. v. 1837, Wilbur's basin, on leaves; 3384, Salem, NY, 7. vi. 1837, in woods on the wing; 3418, Stillwater, NY, 9. vi. 1837, near grandmother's; 7700-06, Salem, NY, iii. 1844, on melting snow; 10,077-078, 27. iii. 1845, on willows, north bank of Black Creek; 10,067-070, 5. iv. 1845, in meadow, on snow; *635, Salem, NY, 15. iv. 1845, on big hill, on the wing; *737, Salem, NY, 26. iv. 1845, flying, Jarvis Martin's woods; 12,404-433, 12,466, Salem, NY, Spring, 1847, various situations.

Family CAPNIIDAE

25. **Perla nivicola** Fitch, 1847g:278.
Allocapnia nivicola (Fitch).
Original Specimens:7710-13, Salem, NY, iii. 1844, on melting snow; 10,057-060, Salem, NY, 7. iv. 1845, on snow, Jarvis Martin's woods; *4223-47, Salem, NY, 2. ii. 1847, on melting snow along the outlet of McDougall's Lake; *4269-82, Salem, NY, 4. iii. 1847, on melting snow, woodlot, by McDougall's Lake.
Extant Specimens: *4224/ *P. nivicola*, A. Fitch/Hagen/ Type, 10114 (MCZ).

Order ORTHOPTERA

Family TETTIGONIIDAE

26. **Acanthodis macrocerus** Fitch, 1857m:489.
Original Specimens:Acapulco, Mexico or Martinique, 1854.

Family OECANTHIDAE

27. **Oecanthus niveus augustipennis** Fitch, 1857m:413.
Oecanthus niveus Degeer.

28. **Oecanthus niveus discoloratus** Fitch, 1857m:413.
Oecanthus niveus discoloratus Fitch.
Original Specimens:5937, Tullehassie, AR, 1852, from Wm. S. Robertson.

29. **Oecanthus niveus fuscipes** Fitch, 1857m:413.
Oecanthus niveus fuscipes Fitch.
Original Specimens:1851, New Brunswick, NJ, 23. ix. 1851, upon walnut and oak leaves.

Order PSOCOPTERA

Family PSOCIDAE

30. **Psocus aceris** Fitch, 1862g:162.
Original Specimens: Salem, NY, 29. vii. 1854, on maple and shad bark, from J. McDonald.

31. **Psocus tritici** Fitch, 1847f:151.
Original Specimens:11,818, 23. vii. 1846, on wheat stalks; 12,019-021, Salem, NY, 23. ix. 1846, on Mrs. Fitch's barn floor.

Order HEMIPTERA

Family CICADIDAE

32. **Cicada robertsonii** Fitch, 1855n:745.
Tibicen resh (Haldeman).
Original Specimens:1113, Tullehassie, west of AR, 1850, taken by Wm. S. Robertson.

33. **Cicada superba** Fitch, 1855n:745.
Tibicen superbus (Fitch).
Original Specimens:3015, Tullehassie, west of AR, summer, 1851, from Wm. S. Robertson.

Family MEMBRACIDAE

34. **Smilia auriculata** Fitch, 1851a:49.
Archasia galeata (Fabricius).
Original Specimens:5101, Stillwater, NY, 15. vii. 1847, on oak bushes.
Extant Specimens:676/Male/Type (NYSM).
Note: There are two specimens from Fitch's collection in the USNM. They are labelled 10,188, and 875 in Fitch's handwriting in red ink. The latter is overscored, and it is also labelled "Fitch's Type." Neither of these specimens can be considered part of Fitch's type series because, according to his manuscript notes, both were obtained from Wm. S. Robertson in 1855, four years after the original description was published.

35. **Ceresa brevicornis** Fitch, 1857m:451.
Stictocephala brevicornis Fitch.
Original Specimens: 1875, New Brunswick, NJ, 23. ix. 1851, on walnut bushes.
Extant Specimens:Fitch's Type/Fitch's Collection/ 1875/ Type No. 599/USNM/ *Ceresa brevicornis* (Type) Fitch (USNM).

36. **Uroxiphus caryae** Fitch, 1851a:52.

Microcentrus caryae (Fitch).

Original Specimens: *3921, Salem, NY, 11. viii. 1846, on walnut, Titus's hill; *3992-97, Greenwich, NY, 24. viii. 1846, on shag-bark hickory, near P. C. Dunlap's; *6073-76, Salem, NY, 19. viii. 1847, on shag-bark hickory, Titus's hill; *6276-77, Salem, NY, 4. ix. 1847, on walnut, northwest corner of Mill Lot; *6646-47, Greenwich, NY, 20. ix. 1847, on pig-walnut, along Cossayuna Lake; 13,273, Stillwater, NY, vii. 1848, on walnut bushes; 1879, New Brunswick, NJ, 23. ix. 1851, on walnut leaves.

Extant Specimens: *3992/ *Uroxyphus caryae* Fitch/257 (MCZH); *3997 (MCZH); 700/Male. /Type (NYSM); 701/ Female (NYSM).

37. **Smilia castaneae** Fitch, 1851a:49.

Atymna castaneae (Fitch).

Original Specimens:3847, Stillwater, NY, 6. vii. 1837, on leaves, near grandmother's; 3955, 3957-58, Stillwater, NY, 8. vii. 1837, near grandmother's; 4179-80, Stillwater, NY, 12. vii. 1837, meadow east of grandmother's; 11,746-749, 11,754-755, Stillwater, NY, 16. vii. 1846, on oaks in big swamp; 11,765, 11,794, 11,796, Stillwater, NY, on chestnut bushes, west of grandmother's; *3597-98, Salem, NY, 24. vii. 1846, on chestnut tree, Jarvis Martin's woods; *3914-15, Salem, NY, 11. viii. 1846, on chestnut, Sidney Martin's back pasture; *4978, Salem, NY, forepart of July, 1847; *5180, Stillwater, NY, 15. vii. 1847, on chestnut bushes; *6924, Long Island, NY, 1847, from Wm. S. Robertson.

Extant Specimens:Fitch's Type/Fitch's Collection/ *4978/ Type No. 601, U. S. N. M. / *S. castaneae*, Fh. (USNM); 669/ Male/Type (NYSM); 670/Female (NYSM); 671/Var. a (NYSM).

38. **Telemona concava** Fitch, 1851a:50.

Telamona concava Fitch.

Original Specimens:5419, Stillwater, NY, 1834, a female.

Extant Specimens:686/Female/Type (NYSM).

Note: A specimen in the USNM collection bears Fitch's label 2133, and it is also labelled "Fitch's Type, Fitch's collection, No. 608, U. S. N. M., *Telemona concava* Fh." Fitch's manuscript notes and specimen registers show that he did not have a specimen of *T. concava* numbered 2133, so this specimen cannot be a type.

39. **Telamona coryli** Fitch, 1851a:51.

Telemona tristis Fitch.

Original Specimens: *3072, Salem, NY, 24. vi. 1846, on hazel-nut bushes on the big hill.

Extant Specimens:690/Female/Type (NYSM).

40. **Thelia crataegi** Fitch, 1851a:52.

Glossonotus crataegi (Fitch).

Original Specimens: *3647-48, Salem, NY, 27. vii. 1846, on a thorn bush near the Batten Kill, upper corner of Esq. Martin's meadow; *5665-66, Salem, NY, 8. viii. 1847, on thorn bush, Esq. Martin's field.

Extant Specimens:697/Type (NYSM); Female (NYSM).

Note: A specimen in the USNM collection bears Fitch's label **4416, and it is also labelled "Fitch's Type, Fitch's Collection, Type No. 602, U. S. N. M., *Thelia* Amy. + Ser., *crataegi* Fitch, New York." According to Fitch's specimen registers, this specimen was collected in 1854, and, therefore, it is not part of the original type series.

41. **Tragopa dorsalis** Fitch, 1851a:52.

Micrutalis dorsalis (Fitch).

Original Specimens: *3657-59, Salem, NY, 27. vii. 1846, on *Cornus paniculata* in Esq. Martin's meadow; *3870, Salem, NY, 6. viii. 1846, on grape vines, in the meadow; *5244, Salem, NY, 21. vii. 1847, on sumach, in Sidney Martin's meadow; *7929-31, Salem, NY, 25. vii. 1848, on grape vine, Esq. Martin's meadow; **132-142, Salem, NY, 25. vii. 1851, on grape vine, in the meadow; **116, Salem, NY, 25. vii. 1851, on sumach, in the meadow; 3141, Windsor, MA, vii. 1851, from T. B. Ashton; **478, Salem, NY, x. 1851, on chestnut, on Titus's hill.

Extant Specimens: **134/ *Tragopa dorsalis* Fitch/256 (MCZH); **137/256A (MCZH); 698/Male/Type (NYSM); 699/Female (NYSM).

42. **Telamona fagi** Fitch, 1851a:51.

Heliria fagi (Fitch).

Original Specimens: **3340, Salem, NY, 13. vii. 1846, on beech tree, by big hill, male.

Extant Specimens:687/Male/Type (NYSM).

Note: A specimen in the USNM collection bears Fitch's label *9844, and it is also labelled "Fitch's Type, Fitch's Collection, Type No. 609, U. S. N. M., *T. fagi*, Fh." Fitch's manuscript notes and specimen registers show that he did not have a specimen of *T. fagi* numbered *9844, so this specimen cannot be a type.

43. **Telemona fasciata** Fitch, 1851a:50.

Telemona unicolor Fitch.

Original Specimens: *3923, Salem, NY, 11. viii. 1846, on walnut bushes, Titus's hill.

Extant Specimens:685/Female/Type (NYSM).

Note: A specimen in the USNM collection bears Fitch's label 14,496, and it is also labelled "Fitch's Type, Fitch's Collection, Type No. 605, U. S. N. M., *T. fasciata*, Fh." According to Fitch's specimen registers, this specimen was collected in 1856, and, therefore, it is not part of the original type series.

44. **Cyrtoisa fenestrata** Fitch, 1851a:49.

Cyrtolobus fenestratus (Fitch).

Original Specimens:132-139, East Greenwich, R. I., viii. 1846, from Pliny F. Martin; *6922, *6926-27, Long Island, NY, 1847, from Wm. S. Robertson; *5365, Salem, NY, 23. vii. 1847, on white oak, dugway woods; *6171, Salem, NY, 21. viii. 1847, on white pine, near McDougall's Lake; *6234, Salem, NY, 4. ix. 1847, on white oak, northwest corner of mill lot.

Extant Specimens:Fitch's Type/*6926/Fitch's Collection/ Female/Type No. 599, U.S.N.M./*C. fenestrata*, Fh. (USNM); *6927/*Cyrtosia fenestrata* Fitch/237 (MCZH); 678/Male/Type (NYSM); Female (NYSM).

45. **Smilia vittata guttata** Fitch, 1851a:49.

Smilia camelus (Fabricius).

Original Specimens: *3122-28, Salem, NY, 26. vi. 1846, on bushes of red? oak in Jarvis Martin's woods; *3306-22, Salem, NY, 11. vii. 1846, on black oak bushes (*Q. tinctoria*), southeast corner of Mrs. Fitch's woods; 11,753, Stillwater, NY, 16. vii. 1846, on oaks in the big swamp; *4633, Salem, NY, 28. vi. 1847, on oaks, Jarvis Martin's woods.

Extant Specimens:675/Subsp. *guattata* (NYSM).

46. **Enchophyllum ensatum intermedia** Fitch, 1857m:465.

47. **Telemona unicolor irrorata** Fitch, 1857m:450.
Telemona unicolor Fitch.

48. **Smilia querci** Fitch, 1851a:49.
Atymna querci (Fitch).
Original Specimens: *4530-31, Salem, NY, 26. vi. 1847, on oaks, dugway hill; *4834, Salem, NY, 5. vii. 1847, on white oak in Esq. Martin's pasture. *6931-32, Long Island, NY, 1847, from Wm. S. Robertson.
Extant Specimens: *6931/Fitch's Type/Fitch's Collection/ Type No. 600, U.S. N.M./*S. querci*, Fh. (USNM); 672/Type (NYSM); 673/Var. a (NYSM); Male (NYSM).

49. **Telemona querci** Fitch, 1851a:51.
Telemona monticola (Fabricius).
Original Specimens: *3033, Salem, NY, 24. vi. 1846, on the big hill, on white oak trees; *3108-09, Salem, NY, 26. vi. 1846, beat from oak bushes in Jarvis Martin's woods; *3136, Greenwich, NY, 29. vi. 1846, border of woods north of Peter Dunlap's, on an oak bush; *3302, Salem, NY, 11. vii. 1846, on young branches of black oak (*Quercus tinctoria*), southeast corner of Mrs. Fitch's woods; 11,783, Stillwater, NY, 16. vii. 1846, on oaks, west of grandmother's; *3876, Salem, NY, 11. viii. 1846, on white oaks, Titus's hill; 143, East Greenwich, RI, viii. 1846, from Pliny F. Martin; *4681, Salem, NY, 28. vi. 1847, on thorn, Jarvis Martin's woods; *4631-32, Salem, NY, 28. vi. 1847, on oaks, Jarvis Martin's woods; *6014, Salem, NY, 19. viii. 1847, on white oaks, Titus's hill; *6918, Long Island, NY, 1847, from Wm. S. Robertson.
Extant Specimens: *3109/Fitch's Collection/*T. querci*, Fh./ Type No. 603, U.S.N.M./F.W.G., *Telamona querci* Fh. (USNM); 691/Male/Type (NYSM); 692/Female (NYSM).

50. **Telamona reclivata** Fitch, 1851a:51.
Telamona reclivata Fitch.
Original Specimens:11,769, Stillwater, NY, 16. vii. 1846, west of grandmother's; 11,793, Stillwater, NY. 16. vii. 1846, on chestnut bushes west of grandmother's; *3695, Salem, NY, 27. vii. 1846, on black oak in Esq. Martin's pasture; *3787, Salem, NY, 29. vii. 1846, on white oak on dugway hill; 12,727, Canajoharie, NY, from Wm. S. Robertson.
Extant Specimens:693/Type (NYSM).
Note: A specimen in the USNM Collection bears Fitch's label **5979, and it is also labelled "Fitch's Type, Fitch's Collection, *T. reclivata*, Fh., Type No. 606, U. S. N. M." Fitch's manuscript notes and specimen registers show that he did not have a specimen of *T. reclivata* numbered **5979, so this specimen cannot be a type.

51. **Ceresa taurina** Fitch, 1857m:335.
Stictocephala taurina (Fitch).
Original Specimens: *3573, *3575, Salem, NY, 24. vii. 1846, on beech trees, Jarvis Martin's woods; *3668, Salem, NY, 27. vii. 1846, on maple, by Batten Kill, Esq. Martin's farm; 13,275, 13,291, Stillwater, NY, vii. 1848, on walnut and on oak bushes; 10,179, Salem, NY, 15. viii. 1851, in front yard; 13,435, Whitestown, NY, 16. ix. 1851, on *Aster* and *Solidago* flowers.
Extant Specimens:Fitch's Type/Fitch's Collection/*3668/ *Ceresa taurina*, H. Cat./Type No. 596, U.S.N.M./(Type) Fitch (USNM).

52. **Entilia sinuata torva** Fitch, 1851a:47.
Entylia carinata Forster.
Original Specimens:2302, Salem, NY, 1831; 3848, Stillwater, NY, 6. vii. 1837, on leaves, near grandmother's; 8565, Salem, NY, 23. vi. 1844, on a Canada thistle, protected by ants; *8556-58, Salem, NY, 20. v. 1846, on trees, northwest corner of mill lot; *2680-81, Salem, NY, 20. v. 1846, on pine trees, northwest corner of mill lot; *3987, Greenwich, NY, 24. viii. 1846, on chestnut trees, near P. C. Dunlap's; *4152, Salem, NY, 11. xi. 1846, on pine trees, dugway woods; *6663, Greenwich, NY, 20. ix. 1847, on shrubs along Cossayuna Lake; *7353, Salem, NY, 12. v. 1848, on pines, Jarvis Martin's woods; 12,592, Salem, NY, 17. ix. 1850, on pines, northwest corner of mill lot.
Extant Specimens:647/Subsp. *torva* (NYSM).

53. **Telemona tristis** Fitch, 1851a:51.
Telemona tristis Fitch.
Original Specimens: *3907, Salem, NY, 11. viii. 1846, on *Ostrya*, on Titus's hill; *5547, Salem, NY, 29. vii. 1847, on *Cornus paniculata*, north side of Black Creek, *6372, Salem, NY, 10. ix. 1847, on hazelnut bushes, Esq. Martin's meadow.
Extant Specimens:Female (NYSM); 689/Type (NYSM).
Note: A specimen in the USNM collection bears Fitch's label **102, and it is also labelled "Fitch's Type, Fitch's Collection, *T. tristis*, Fh., Type No. 607, U. S. N. M., *T. coryli* Fitch." Fitch's manuscript notes and specimen registers show that he did not have a specimen of *T. tristis* numbered **102, so this specimen cannot be a type.

54. **Telemona unicolor** Fitch, 1851a:50.
Telemona unicolor Fitch.
Original Specimens: 5420, Stillwater, NY, 1834; 13,274, Stillwater, NY, vii. 1848, on walnut bushes, west of grandmother's; 1878, New Brunswick, NJ, 23. ix. 1851, on walnut bushes.
Extant Specimens:684/Female/Type (NYSM).
Note: A specimen in the USNM collection bears Fitch's label **1800, and it is also labelled "Fitch's Type, Fitch's Collection, *T. unicolor*, Fh., Type No. 604, U. S. N. M." According to Fitch's specimen registers, this specimen was collected in 1852, and, therefore, it is not part of the original type series.

Family CICADELLIDAE

55. **Athysanus abietis** Fitch, 1851a:60.
Oncopsis variabilis (Fitch).
Original Specimens: *2724, Salem, NY, 20. v. 1846, on birch, northwest corner of mill lot; 475-477, Winhall, VT, 17. vi. 1847, on spruce and fir shrubs, near summit of Green Mountains; *4622, Salem, NY, 28. vi. 1847, on birch, Jarvis Martin's woods; *9894, Salem, NY, 9. vi. 1851, on grass, west border of Jarvis Martin's woods.
Extant Specimens:793 (NYSM); Female (NYSM).

56. **Erythroneura affinis** Fitch, 1851a:63.
Erythroneura affinis Fitch.
Note: According to McCabe and Johnson (*Bull. N. Y. State Museum*, 434, 1980), the type (No. 822) has been destroyed.

57. **Idiocerus alternatus** Fitch, 1851a:59.
Idiocerus alternatus Fitch.
Original Specimens:796-97, Salem, NY, 28. iv. 1845, on willow flowers by Black Creek; *5603, Salem, NY, 29. vii. 1847, on grape vine, meadow north of Black Creek; *7289-93, Salem, NY, 12. v. 1848, on black currant bushes, in meadow; *7457, Jackson, NY, 25. v. 1848, on willow, near red bridge; *8437, Salem, NY, 25. iv. 1851, on a pool of water, in the meadow; *8641, *8646, Salem, NY, 7. v. 1851, on willows, in the meadow; *8665-66; Salem, NY, 7. v. 1851, on weeds, in the meadow; *8827-32, Salem, NY, 10. v. 1851, on willows, Esq. Martin's meadow; *8994-95, Salem, NY, 12. v. 1851, on willows, Harvey's meadow; *9074-75, Salem, NY, 19. v. 1851, on willows, in my meadow; *9955, Salem, NY, 12. vii. 1851, on willows, in my meadow.
Extant Specimens: Fitch's Type/Fitch's Collection (USNM); *8665/ *Idiocerus alternatus* Fitch/175 (MCZH); *8828/175A (MCZH); 9075/175B (MCZH); 779/Male (NYSM); 780/Female (NYSM).

58. **Penthimia americana** Fitch, 1851a:57.
Penthimia americana Fitch.
Original Specimens: *7461-62, Jackson, NY, 25. v. 1848, on maples, near the red bridge; 1089, Tullehassie, AR, 1850, from Wm. S. Robertson.
Extant Specimens:Fitch's Type/Fitch's Collection/ Arkansas, W. S. Robertson (USNM); 760/Male (NYSM); 761/ Female (NYSM).
Note: A specimen in the USNM collection bears Fitch's label *498 in red ink, and it is also labelled "Fitch Type, Fitch Collection, *Penthimia americana* Fitch, New York." According to Fitch's specimen registers, this specimen was collected in "Tullehassie, Ark." in 1855, and, therefore, it is not part of the original type series.

59. **Empoa coccinea** Fitch, 1851a:63.
Empoasca coccinea (Fitch).
Original Specimens: *4932, Salem, NY, 5. vii. 1847, on pine leaves in pine woods (State Cabinet).

60. **Helochara communis** Fitch, 1851a:56.
Helochara communis Fitch.
Original Specimens:2490, Salem, NY, 1827; 1231-32, Stillwater, NY, 22. iv. 1837, on surface of water at the "Fly Bridge" — in swamp north of village; 6849-52, Salem, NY, 1838; *799 Salem, NY, 28. iv. 1845, in meadow south of Black Creek; *1995, Salem, NY, 6. iv. 1846, in woods on big hill; *2068, Salem, NY, 20. iv. 1846, among grass in the meadow; *2134-37, Salem, NY, 21. iv. 1846, among grass growing in a pool of water upon Jarvis Marten's hills; *2384, Salem, NY, 6. v. 1846, on dry bed of sand in the meadow; *4109-18, Salem, NY, 10. xi. 1846, on grass in meadow in vast numbers; 12,475, Salem, NY, Spring 1847; *5895, Salem, NY, Spring 1847, on Harvey Fitch's flat, near the spring; 456-47, Winhall, VT, 17. vi. 1847, near top of Green Mountains; *6130, Salem, NY, 21. viii. 1847, on blackberry bushes near McDougall's Lake; 12,664-666, Salem, NY, 15. xi. 1850, abundant on grass in a wet situation, by the swamp in Mrs. Fitch's back field; 12,699, Salem, NY, 15. xi. 1850, on grass; *8436, Salem, NY, 25. iv. 1851, on pools of water in the meadow; *8497-99, Salem, NY, 26. iv. 1851, on pools of water in the meadow; *8556-57, 29. iv. 1851, on pools of water in the meadow; *8760-61, Salem, NY, 10. v. 1851, on grass in a marshy spot, Titus's hill; *9574-75, Salem, NY, 9. vi. 1851, on grass in a marshy spot, by Jarvis Martin's woods; *9948, Salem, NY, 12. vi. 1851, on grass, damp ground, in meadow; *9997-99, Salem, NY, 21. vii. 1851, on grass and rushes, marshy ground, in meadow; **10,060, Salem, NY, 22. vii. 1851, on rushes, by water in the meadow.
Extant Specimens: *8761/140B (MCZH); Fitch's Type/ Fitch's Collection/ *Helochara communis* Fitch (USNM, 2 specimens); 753/Male (NYSM); 754/Female (NYSM); 755/Var. a (NYSM).
Note: Two specimens in the USNM Collection, bearing Fitch's labels 3459 and 6922 in red ink, and also labelled "Fitch's Collection," are from Mississippi and were collected in 1852. Therefore, they are not part of the original type series.

61. **Amblycephalus curtesii** Fitch, 1851a:61.
Amblysellus curtisii (Fitch).
Original Specimens: *2972, Jackson, NY, 16. vi. 1846, on birch tree beside the kill below Deacon Small's; 11,816, Stillwater, NY, 16. vii. 1846, hills west of grandmother's; *4663, Salem, NY, 28. vi. 1847, on walnut, Jarvis Martin's woods; *4910, Salem, NY, 5. vii. 1847, on grass, Esq. Martin's pasture; *4950, Salem, NY, 8. vii. 1847, in the office; *5230, Salem, NY, 21. vii. 1847, on sugar maple, Sidney Martin's meadow; *5252, Salem, NY, 21. vii. 1847, on sumach, Sidney Martin's meadow; *5539, Salem, NY, 29. vii. 1847, on *Cornus panic*; north of Black Creek; *6452-57, Salem, NY, 10. ix. 1847, on grass, Esq. Martin's meadow; 12,658-659, Salem, NY; 12. ix. 1850, on grass in meadow; 12,701-703, Salem, NY, 22. xi. 1850, on grass in front yard; *9886, Salem, NY, 5. vii. 1851, on grass in the meadow; 13,382-383, Whitestown, NY, 16. ix. 1851, bushes along the Mohawk R.; *10,346, Salem, NY, 20. xi. 1851, on snow, on the wood lot by McDougall's Lake.
Extant Specimens: 12,702/ *Amblycephalus curtisii* Fitch/164 (MCZH); *Amblycephalus curtisii* Fitch, New York/Fitch's Collection (USNM); Var. a/Fitch's Type/Fitch's Collection (USNM); Fitch's Type/Fitch's Collection (USNM); 798/Male (NYSM); 799/Female (NYSM).

62. **Athysanus fagi** Fitch, 1851a:61.
Oncopsis fagi (Fitch).
Original Specimens: *2847, Granville, NY, 11. vi. 1846, on leaves of beech tree.
Extant Specimens: 796/Female (NYSM).

63. **Athysanus fenestratus** Fitch, 1851a:60.
Oncopsis fitchi Van Duzee.
Original Specimens: *2970, Jackson, NY, 16. vi. 1846, on white birch; *3367, Salem, NY, 13. vii. 1846, on white birch near foot-bridge in meadow; *4621, Salem, NY, 28. vii. 1846, on birch, Jarvis Martin's woods.
Extant Specimens:*Athysanus fenestratus* Fitch, New York/ Fitch's Type/Fitch's Collection (USNM); 794 (NYSM); Female (NYSM).

64. **Gypona flavilineata** Fitch, 1851a:57.
Gyponana flavilineata (Fitch).
Original Specimens: 2479, Salem, NY, 1827; 4806, Stillwater, NY, x. 1837; *3170, Salem, NY, 3. vii. 1846, on

Carpinus americ. in Harvey's meadow; *3231, Greenwich, NY, 6. vii. 1846, in woods north of P. C. Dunlap's; *3342-44, Salem, NY, 13. vii. 1846, on bushes near foot bridge over White Creek; *3366, Salem, NY, 13. vii. 1846, on white birch near foot bridge over White Creek; 11,736, Stillwater, NY, 16. vii. 1846, on bitter walnut, southwest of grandmother's; *3576-78, Salem, NY, 24. vii. 1846, on beech trees, Jarvis Martin's woods; *3786, Salem, NY, 29. vii. 1846, on white oak, along edge of dugway woods; *3884, Salem, NY, 11. viii. 1846, on white oaks, S. Martin's back pasture; *5171-72, Stillwater, NY, 15. vii. 1847, on walnut bushes; *5538, Salem, NY, 29. vii. 1847, on *Cornus paniculata*, north side of Black Creek; *5944, Salem, NY, 19. viii. 1847, pasture over the creek; *6049, Salem, NY, 19. viii. 1847, east side of Mrs. Fitch's woods on maple; *6070-72, Salem, NY, 19. viii. 1847, east side of Mrs. Fitch's woods, on hickory; *6109-10, Salem, NY, 19. viii. 1847, east side of Mrs. Fitch's woods, pupae; *6148-49, Salem, NY, 21. viii. 1847, on beech, about McDougall's Lake; *6229-30, Salem, NY, 4. ix. 1847, on white oaks, northwest corner of mill lot; *6304, Salem, NY, 10. ix. 1847, on willows, Esq. Martin's meadow; *6624, Greenwich, NY, 20. ix. 1847, on maples, by Cossayuna Lake; 1150, Tullehassie, AR, Spring 1850, from Wm. S. Robertson; 3083-84, Tullehassie, West of AR, vii. 1851, from Wm. S. Robertson; 13,430-31, Whitestown, NY, 16. ix. 1851, on *Aster* and *Solidago* flowers by Mohawk R.

Extant Specimens: *6304/148 (MCZH); P. R. Uhler Collection/ *Gypona flavilineata* Fitch, Type, Male (USNM); Fitch's Type/Fitch's Collection/Type No. 629 (USNM); 757/ Male (NYSM); 758 (NYSM); Female/Paratype of *Gypona flavilineata* Fitch (#7584) (NYSM).

Note: A specimen in the USNM collection, bearing Fitch's label 6706, and also labelled "Fitch's Type, Fitch's Collection, *Gypona flavilineata* Fh., female, Type No. 629" is from Tullehassie, Arkansas, October 1852, according to Fitch's specimen registers. It is, therefore, not part of the original type series.

65. **Jassus fulvidorsum** Fitch, 1851a:62.

Paraphlepsius fulvidorsum (Fitch).

Original Specimens: *6139-40, Salem, NY, 21. vii. 1847, on black birch, near McDougall's Lake; *6173-78, Salem, NY, 21. viii. 1847, on white pine, near McDougall's Lake; 12,631, Salem, NY, 14. ix. 1850, on wild poplars, south side of big hill.

Extant Specimens: *6178/ *Jassus fulvidorsum* Fitch/158 (MCZH); Fitch's Type/Fitch's Collection/ *Jassus fulvidorsum* Fitch, Wash'tn. Co., New York (USNM); 816/Male (NYSM); 817/Female (NYSM).

66. **Idiocerus lachrymalis** Fitch, 1851a:58.

Idiocerus lachrymalis Fitch.

Original Specimens:11,611, Salem, NY, 30. vi. 1846, beat from a hemlock tree in Jarvis Martin's woods; *3920, Salem, NY, 11. viii. 1846, on walnut bushes, S. Martin's back pasture; *6062-64, Salem, NY, 19. viii. 1847, on wild poplar, east side of Mrs. Fitch's woods; 12,626-29, Salem, NY, 14. ix. 1850, on poplar bushes, south side of big hill.

Extant Specimens:773/Male (NYSM); 774/Female (NYSM); 775/var. a (NYSM); 776/var. b (NYSM); 777 var. c (NYSM); 778/var. d (NYSM).

67. **Idiocerus maculipennis** Fitch, 1851a:59.

Idiocerus fitchi Van Duzee.

Original Specimens: *3649, Salem, NY, 27. vii. 1846, on thorn bushes in Esq. Martin's meadow; *4674, Salem, NY, 28. vi. 1847, on thorn, Jarvis Martin's woods.

Extant Specimens: Fitch's Type/Fitch's Collection/ *Idiocerus maculipennis* Fitch, New York (USNM).

68. **Amblycephalus melsheimerii** Fitch, 1851a:61.

Laevicephalus melsheimerii (Fitch).

Original Specimens: *4911, Salem, NY, 5. vii. 1847, on grass in Esq. Martin's pasture; *4933, Salem, NY, 5. vii. 1847, on pine bushes, pine woods; *6141, Salem, NY, 21. viii. 1847, on black birch, by McDougall's Lake; 12,526, Salem, NY, 1847, about the house; 12,686-695, Salem, NY, 15. xi. 1850, on grass.

Extant Specimens: *4911/ *Amblycephalus melsheimerii* Fitch/163 (MCZH); 12,691/P. R. Uhler Collection/ *Amblycephalus melsheimerii*! Fitch, Det. Uhler (USNM); *Amblycephalus melsheimerii* Fitch, New York/Fitch's Type/ Fitch's Collection/Not on pin 3.iii.31 (USNM); 806/Female (NYSM).

69. **Athysanus minor** Fitch, 1851a:60.

Oncopsis fitchi Van Duzee.

Original Specimens: *2977, Jackson, NY, 16. vi. 1846, on white birch tree, beside the kill; 11,608, Salem, NY, 24. vi. 1846, on the big hill?; *3073, *3076, Salem, NY, 24. vi. 1846, on hazelnut bushes, Battle Hill; *3368, Salem, NY, 13. vii. 1846, on white birch, near foot bridge, in meadow; *3611, Salem, NY, 24. vii. 1846, on birch tree leaves, Jarvis Martin's woods; *4867-74, Salem, NY, 5. vii. 1847, on black and white birch along the kill, in Esq. Martin's fields; *4997-98, Salem, NY, 10. vii. 1847, on white birch near foot bridge; *5663, Salem, NY, 6. viii. 1847, on black cherry tree, Esq. Martin's field; *6138, Salem, NY, 21. viii. 1847, on black birch, near McDougall's Lake; 10,112, Salem, NY, 25. vii. 1851, on birch, border of the meadow.

Extant Specimens: *4869/ *Athysanus minor* Fitch/173 (MCZH); *Athysanus minor* Fitch/Fitch's Type/Fitch's Collection (USNM); 795 (NYSM); Female (NYSM).

70. **Athysanus nigrinasi** Fitch, 1851a:61.

Oncopsis nigrinasi (Fitch).

Original Specimens: *2983, Jackson, NY, 16. vi. 1846, on *Carpinus*, bank of kill below Deacon Small's; *3082, Salem, NY, 24. vi. 1846, on white birch, by foot bridge; *3054, Salem, NY, 24. vi. 1846, on birch?, on Battle Hill; *3166-67, Salem, NY, 3. vii. 1846, on *Carpinus*, in Harvey's meadow; *3185, Salem, NY, 3. vii. 1846, on butternut, in Harvey's meadow; *3610, Salem, NY, 24. vii. 1846, on birch, Jarvis Martin's woods; *3686, Salem, NY, 27. vii. 1846, on *Carpinus* in Esq. Martin's meadow; *3742-45, Salem, NY, 28. vii. 1846, on *Carpinus* in the meadow; *5290, Salem, NY, 21. vii. 1847, on *Carpinus*, Sidney Martin's meadow.

Extant Specimens: *2983/ *Athysanus nigrinasi* Fitch/170 (MCZH); *Athysanus nigrinasi* Fitch, New York/Fitch's Type/ Fitch's Collection/(USNM); 797 (NYSM); Female (NYSM).

71. **Aulacizes noveboracensis** Fitch, 1851a:56.

Draeculacephala noveboracensis (Fitch).

Original Specimens: *6581, Salem, NY, 11. ix. 1847, on the grass, in Esq. Martin's meadow; *9935-39, Salem, NY,

12. vii. 1851, on grass in the meadow; *10,056-58, Salem, NY, 22. vii. 1851, on rushes, by the water in the meadow; *10,093, Salem, NY, 22. vii. 1851, on brakes, lower island in the meadow.

Extant Specimens: *9936/ *Aulacizes noveboracensis* Fitch/ 144 (MCZH);752/Female (NYSM).

Note: Two specimens in the USNM collection bear Fitch's labels **1964 and *2032, and they are also labelled as Fitch's types. According to Fitch's specimen registers these specimens were collected in 1852, and, therefore, they are not part of the original type series.

72. **Evacanthus orbitalis** Fitch, 1851a:57.

Evacanthus acuminatus (Fabricius).

Original Specimens: *5457, Salem, NY, 27. vii. 1847, on *Cornus paniculata*, Esq. Martin's meadow; *5544, Salem, NY, 29. vii. 1847, on *Cornus paniculata*, meadow along Black Creek; *10,077-086, Salem, NY, 22. vii. 1851, on brakes, lower island in the meadow; *10,110, Salem, NY, 25. vii. 1851, on brakes, lower island in the meadow.

Extant Specimens:Fitch's Type/Fitch's Collection/ *Evacanthus orbitalis* Fitch, New York/Type No. 628, (USNM); Fitch's Type/Fitch's Collection/Var. a (USNM); 756/Male (NYSM).

73. **Idiocerus pallidus** Fitch, 1851a:59.

Idiocerus pallidus Fitch.

Original Specimens: *3717, Salem, NY, 28. vii. 1846, on maples along the creek in the meadow; *5002, Salem, NY, 10. vii. 1847, attracted by candle light; *5183, Stillwater, NY, 15. vii. 1847, on chestnut bushes; *6059-61, Salem, NY, 19. viii. 1847, on wild poplars, east side of Mrs. Fitch's woods; *6309-14, Salem, NY, 10. ix. 1847, on willows, Esq. Martin's meadow; *6507-09, Salem, NY, 11. ix. 1847, on willows, Esq. Martin's meadow; 12,622-623, Salem, NY, 14. ix. 1850, on wild poplar, south side of big hill; *9831-35, Salem, NY, 5. vii. 1851, on willows, in the meadow; *10,098, Salem, NY, 22. vii. 1851, in the house, in the evening; *10,148, Salem, NY, 25. vii. 1851, on grape vine in the meadow.

Extant Specimens: *6059/ *Id. pallidus* Fitch/178 (MCZH); *9834/178A (MCZH); *Idiocerus pallidus* Fitch, New York/ Fitch's Type/Fitch's Collection (USNM).

74. **Empoa querci** Fitch, 1851a:63.

Empoa querci Fitch.

Original Specimens: *3044-51, Salem, NY, 24. vi. 1846, beat from white oak trees on the big hill, 11,808-809, Stillwater, NY, 16. vii. 1846, hills west of grandmothers; *4840, Salem, NY, 5. vii. 1847, on white oak in Esq. Martin's pasture; *5123-25, Stillwater, NY, 15. vii. 1847, on oak bushes; *5164, Stillwater, NY, 15. vii. 1847, on walnut bushes; *5378, Salem, NY, 23. vii. 1847, on white oak, top of dugway hill; *6143, Salem, NY, 21. viii. 1847, on white oak, near McDougall's Lake; 13,295, 13,299, 13,301, Stillwater, NY, vii. 1848, on oak bushes, 1888-89, New Brunswick, NJ, 23. ix. 1851, on oak bushes; *10,473, Salem, NY, 9. x. 1851, on oak bushes, Titus's hill.

Extant Specimens: 13,299/*Empoa querci* Fitch/198 (MCZH).

75. **Amblycephalus sayii** Fitch, 1851a:61.

Latalus sayii (Fitch).

Original Specimens: *3020, Salem, NY, vi. 1846, on plants in the yard; *4695, Salem, NY, 28. vi. 1847, on the wing, Jarvis Martin's woods; *5456, Salem, NY, 27. vii. 1847, on *Cornus paniculata*, Esq. Martin's meadow; *5545, Salem, NY, 29. vii. 1847, on *Cornus paniculata*, meadow north of Black Creek; *6144, Salem, NY, 21. viii. 1847, on white oak, near McDougall's Lake; 499, northwest corner of Arlington, VT, 23. viii. 1847; *6323, Salem, NY, 10. ix. 1847, on willows, Esq. Martin's meadow; *6375, *6378, *6380, Salem, NY, 10. ix. 1847, on hazelnut bushes, Esq. Martin's meadow; *6463-71, *6584, Salem, NY, 10. ix. 1847, on grass, Esq. Martin's Meadow; *7194-95, Salem, NY, late autumn, 1847; 12,606, Salem, NY, 14. ix. 1850, on alder bushes, in meadow; 12,656, Salem, NY, 12. xi. 1850, on grass in meadow; 12,692, Salem, NY, 12. xi. 1850, on grass; 12,704, Salem, NY, 22. xi. 1850, on grass in front yard; *9234, Salem, NY, 30. v. 1851, on weeds, Esq. Martin's meadow; *9433-37, Salem, NY, 5. vi. 1851, on grass, northwest corner of mill lot; *9671, Salem, NY, 17. vi. 1851, on marsh grass, by McDougall's Lake; *9890, Salem, NY, 5. vii. 1851, on grass in the meadow; *10,475, Salem, NY, 9. x. 1851, on oaks, Titus's hill.

Extant Specimens: *9234/ *Amblycephalus sayi* Fitch/162 (MCZH); *Amblycephalus sayii* Fitch, New York/Fitch's Type/ Fitch's Collection (USNM); Fitch's Type/Fitch's Collection/ *Amblycephalus sayi* Fitch (USNM); 800/Male (NYSM); 801/ Female (NYSM); 802/Var. a (NYSM); 803/Var. b (NYSM); 804/Var. c (NYSM).

76. **Gypona scarlatina** Fitch, 1851a:57.

Ponana scarlatina (Fitch).

Original Specimens: *5001, Salem, NY, 10. vii. 1847, attracted into the house by the light of a candle in the evening.

Extant Specimens:N. Y. /P. R. Uhler Collection/ *Gypona scarlatina*, NY/Fitch!/Type! (USNM).

77. **Bythoscopus strobi** Fitch, 1851a:58.

Paraphlepsius strobi (Fitch).

Original Specimens: *2546, *2686-87, Salem, NY, 20. v. 1846, beat from leaves of the white pine, northwest corner of mill lot; *7565-71, Salem, NY, 26. v. 1848, on pines, northwest corner of mill lot; 1104, Tullehassie, AR, spring 1851, from Wm. S. Robertson; *9396-97, Salem, NY, 5. vi. 1851, on pine bushes, mill lot.

Extant Specimens: *9397/ *B. strobi* Fitch/167 (MCZH); *Bythoscopus strobi* Fitch, New York/Fitch's Type/Fitch's Collection (USNM); 772 (NYSM).

78. **Idiocerus suturalis** Fitch, 1851a:59.

Idiocerus suturalis Fitch.

Original Specimens: *5002, Salem, NY, 10. vii. 1847, attracted by light in the evening, in the house; *5183, Stillwater, NY, 15. vii. 1847, beat from chestnut bushes.

Extant Specimens: *Idiocerus suturalis* Fitch, New York/ Fitch's Type/Fitch's Collection (NYSM).

79. **Bythoscopus tergatus** Fitch, 1851a:58.

Chlorotettix tergatus (Fitch).

Original Specimens: *6510, Salem, NY, 11. ix. 1847, on willows in Esq. Martin's meadow.

Extant Specimens:766/Male (NYSM).

80. **Erythroneura tricincta** Fitch, 1851a:63.
Erythroneura tricincta Fitch.
Original Specimens: *6293, Salem, NY, 10. ix. 1847, on black raspberry bushes, in Esq. Martin's meadow; *6331, Salem, NY, 10. ix. 1847, on willows, in Esq. Martin's meadow; *6401-03, Salem, NY, 10. ix. 1847, on grape vines, in Esq. Martin's meadow; *6473, Salem, NY, 10. ix. 1847, on grass, in Esq. Martin's meadow; *6561, Salem, NY, 11. ix. 1847, on grape vines, in Esq. Martin's meadow; *6568, Salem, NY, 11. ix. 1847, on *Cornus paniculata*, in Esq. Martin's meadow; *6604-06, Greenwich, NY, 20. ix. 1847, along the lake, on grape vines.
Extant Specimens: *6402/ *Erythr. tricincta* Fitch/193 (MCZH).

81. **Pediopsis trimaculatus** Fitch, 1851a:60.
Macropsis trimaculata (Fitch).
Original Specimens: *3233, Greenwich, NY, 6. vii. 1846, woods north of P. Dunlap's; *7605, Salem, NY, vi. 1848.
Extant Specimens:785/Female (NYSM).

82. **Tettigonia tripunctata** Fitch, 1851a:55.
Plesiommata tripunctata (Fitch).
Original Specimens: *5543, Salem, NY, 29. vii. 1847, on *Cornus paniculata*, in meadow north of Black Creek.
Extant Specimens:742/Male (NYSM).
Note: Two specimens in the USNM collection bear Fitch's labels **5074 and **5078, and they are also labelled "Fitch's Type." According to Fitch's specimen registers, these specimens were collected in 1854, and, therefore, they are not part of the original type series.

83. **Bythoscopus unicolor** Fitch, 1851a:58.
Chlorotettix unicolor (Fitch).
Original Specimens:6268, Canajoharie, NY, from Wm. S. Robertson; 4946, Stillwater, NY, 14. ix. 1837, on *Solidago* flowers, bank of river; *4909, Salem, NY, 5. vii. 1847, on grass, Esq. Martin's pasture; *5082, Saratoga Springs, NY, 16. vii. 1847, on grass; 498, northeast corner of Arlington, VT, 23. viii. 1847; *6232, Salem, NY, 4. ix. 1847, on white oaks, northwest corner of mill lot; 13,283, Stillwater, NY, vii. 1848, on walnut bushes; 13,294, Stillwater, NY, vii. 1848, on oaks; 12,616, Salem, NY, 14. ix. 1850, on maples, north side of Battle Hill; 12,625, Salem, NY, 14. ix. 1850, on poplar, south side of Battle Hill; 1583-84, Tullehassie, AR, 1. vi. 1851, on grass, from Wm. S. Robertson; 1792-93, 3090-93, Tullehassie, AR, vii. 1851, from Wm. S. Robertson; 3142, Windsor, MA, 25. vii. 1851, from Thos. B. Ashton; 2078, Tullehassie, AR, 20. viii. 1851, from Wm. S. Robertson; 2021-24, Tullehassie, AR, viii. 1851, from Wm. S. Robertson; 1882, New Brunswick, NJ, 23. ix. 1851, on oak or walnut bushes.
Extant Specimens:2021/ *B. unicolor* Fitch/168 (MCZH); *4909/168A (MCZH); Fitch Type/Fitch's Collection/ *Bythoscopus unicolor* Fitch, New York (USNM); 767/Female (NYSM).

84. **Athysanus variabilis** Fitch, 1851a:60.
Oncopsis variabilis (Fitch).
Original Specimens: *2955-69, Jackson, NY, 16. vi. 1846, on a white birch beside Batten Kill; *3181, Salem, NY, 3. vii. 1846, on *Cornus paniculata*, in Harvey's meadow; *3362-64, Salem, NY, 13. vii. 1846, on alders near the foot bridge; *4625-30, Salem, NY, 28. vi. 1847, on birch, Jarvis Martin's woods; *4863, Salem, NY, 5. vii. 1847, on white birch, bank of Batten Kill; *9814-23, Salem, NY, 5. vii. 1851, on alder leaves in the meadow.
Extant Specimens: *9822, *Athysanus variabilis* Fitch/ 171 (MCZH); Fitch's Type/Fitch's Collection/ *A. variabilis* (USNM, 14 specimens); 786/Female (NYSM); 787/Var. a (NYSM); 788/Var. b (NYSM); 789/Var. c (NYSM); 790/Var. d (NYSM); 791/Var. e (NYSM); 792/Var. f (NYSM).

85. **Pediopsis viridis** Fitch, 1851a:59.
Macropsis viridis (Fitch).
Original Specimens: *5169, Stillwater, NY, 15. vii. 1847, beat from walnut bushes; *7889, Salem, NY, 25. vii. 1848, willows, S. Martin's meadow (female, placed in New York State Cabinet of Natural History); *9723, Salem, NY, 23. vi. 1851, on willows, in the meadow; *9811, Salem, NY, 5. vii. 1851, on milkweed flowers, in the meadow; *9836-40, Salem, NY, 5. vii. 1851, on willows, in the meadow; **150-154, Salem, NY, 25. vii. 1851, on willows, in the meadow.
Extant Specimens: *9836/ *Pediopsis viridis* Fitch/185 (MCZH); **153/185A (MCZH); 784/Female (NYSM).

86. **Acocephalus vitellinus** Fitch, 1851a:57.
Fitchana vitellina (Fitch).
Original Specimens:11,791, Stillwater, NY, 16. vii. 1846, hills west of grandmother's; 12,615, Salem, NY, 14. ix. 1850, on maple, north side of big hill; 12,624, Salem, NY, 14. ix. 1850, on poplar, south side of big hill.
Extant Specimens:Fitch's Type/Fitch's Collection (USNM); 762/Female/Male (NYSM); 763/Var. a, Female (NYSM).

87. **Erythroneura vitifex** Fitch, 1857m:392.
Erythroneura vitifex Fitch.
Original Specimens: *6290-91, *6295, Salem, NY, 10. ix. 1847, on black raspberry bushes in Esq. Martin's meadow; *6404-05, Salem, NY, 10. ix. 1847, on grape vine in Esq. Martin's meadow; *6608-18, Greenwich, NY, 20. ix. 1847, on grape vine along Cossayuna Lake; *9083, Salem, NY, 19. v. 1851, on wild currant bushes in the meadow; 1898, New Brunswick, NJ, 23. ix. 1851, on walnut and oak leaves; *10,441, Salem, NY, 8. x. 1851, on alder, in the meadow; 14,532-33, Salem, NY, 2. viii. 1856, on grape vine, in pupa state.

88. **Erythroneura vulnerata** Fitch, 1851a:62.
Erythroneura vulnerata Fitch.
Original Specimens: *1997-98, Salem, NY, 6. iv. 1846, in woods on big hill; *4334, Salem, NY, late in autumn of 1846; *6296-99, Salem, NY, 10. ix. 1847, on black raspberry bushes, Esq. Martin's meadow; *6406, Salem, NY, 10. ix. 1847, on grape vine, Esq. Martin's meadow; *6467, Salem, NY, 10. ix. 1847, on grass, Esq. Martin's meadow; *6567, Salem, NY, 11. ix. 1847, on *Cornus paniculata*, in Esq. Martin's meadow; *6620-21, *6628-30, Greenwich, NY, 20. ix. 1847, on grape vine, along Cossayuna Lake; *7297-99, Salem, NY, 12. v. 1848, on black currant bushes in the meadow; *8037, Salem, NY, 9. vi. 1851, in moss from a tree on the wood lot; 1886, New Brunswick, NJ, 23. ix. 1851, on walnut bushes.
Extant Specimens: *6621/ *Erythr. vulnerata* Fitch/194 (MCZH); *6629/194A (MCZH); *6467 (MCZH); 819/Male (NYSM); 820/Female (NYSM).

Family CERCOPIDAE

89. **Clastoptera proteus cincticollis** Fitch, 1851a:54.
Clastoptera proteus Fitch.
Extant Specimens:725/Var. a (NYSM); 727/Var. c (NYSM).

90. **Clastoptera proteus flavicollis** Fitch, 1851a:54.
Clastoptera proteus Fitch.
Extant Specimens: 723/Var. a (NYSM); 724/ Var. b (NYSM).

91. **Monecphora ignipectus** Fitch, 1857m:389.
Prosapia ignipectus (Fitch).

92. **Clastoptera proteus maculicollis** Fitch, 1851a:54.
Clastoptera proteus Fitch.
Extant Specimens: 729/Var. a (NYSM); 730/ Var. b (NYSM); 731/Var. c (NYSM).

93. **Clastoptera proteus nigricollis** Fitch, 1851a:55.
Clastoptera proteus nigricollis Fitch.
Extant Specimens: 733/Var. a (NYSM); 734/ Var. b (NYSM); 735/Var. c (NYSM); 736/Var. d (NYSM).

94. **Clastoptera pini** Fitch, 1851a:53.
Clastoptera testacea Fitch.
Original Specimens: *5127, Stillwater, NY, 15. vii. 1847, beat from oak bushes; *5327-34, Salem, NY, 23. vii. 1847, beat from leaves of white pine limbs along the top of the dugway hill.
Extant Specimens: *5333/Fitch's Type/Fitch's Collection/ *C. testacea* Fitch, Det. Doering/Type No. 622, U. S. N. M. / *Clastoptera* Germar, *pini* Fitch, New York (USNM); 719/Male (NYSM); 720/Var. a (NYSM); 721/Var. b (NYSM).

95. **Clastoptera proteus** Fitch, 1851a:54.
Clastoptera proteus Fitch.
Original Specimens: *3656, Salem, NY, 27. vii. 1846, on *Cornus paniculata*, in Esq. Martin's meadow; *5477, *5498, *5507, *5509, Salem, NY, 27. vii. 1847, on *Cornus paniculata*, in Esq. Martin's meadow; *5516, *5523, Salem, NY, 29. vii. 1847, on *Cornus paniculata*, north side of Black Creek; *7863, Salem, NY, 25. vii. 1848, border of Esq. Martin's meadow.
Extant Specimens: *3656/ *Clastoptera proteus* Fitch/132 (MCZH); *5477/132A (MCZH); *5507/132C (MCZH); *5516/132B (MCZH); *5523/132D (MCZH); *5509/Fitch's Type/Fitch's Collection/Type No. 624 (USNM); *5498/Type No. 624 (USNM); *7863/Fitch's Type/Fitch's Collection/ Type No. 624 (USNM); 722/Female (NYSM).

96. **Lepyronia saratogensis** Fitch, 1851a:53.
Aphrophora saratogensis (Fitch).
Original Specimens:4660, Stillwater, NY, 2. ix. 1837, about Burgoyne's breastwork, southwest of Wilbur's basin; *3425-27, Stillwater, NY, 16. vii. 1846, west of grandmother's; *3897, Salem, NY, 11. viii. 1846, on poplars, Titus's hill, north of Fitch's point; *3919, Salem, NY, 11. viii. 1846, on walnut, Titus's hill; 11,780, 11,800, Stillwater, NY, 16. vi. 1846, west of grandmother's, on pine; *5098, *5182, Stillwater, NY, 15. vii. 1847, on maple and chestnut bushes; 12,591, Salem, NY, 17. ix. 1850, on pines, northwest corner of mill lot.
Extant Specimens: *5182/Fitch's Type/Fitch's Collection/ *L. saratogensis*, Fh. /Type No. 1021 (USNM); Fitch's Type/ Fitch's Collection/Type No. 1021/ *Aphrophora saratogensis* F. (USNM); 710/Male (NYSM); 711/Female (NYSM); 712/Var. a (NYSM).

97. **Aphrophora signoretii** Fitch, 1857m:388.
Aphrophora signoretii Fitch.
Original Specimens:11,781, Stillwater, NY, 16. vii. 1846, on grape vine (wild).

98. **Clastoptera testacea** Fitch, 1851a:53.
Clastoptera testacea Fitch.
Original Specimens: *3568, Stillwater, NY, 16. vii. 1846, on *Viburnum lentago* bushes, southwest of grandmother's; *3587, Salem, NY, 24. vii. 1846, on pine bushes in Jarvis Martin's woods; *3805-06, Salem, NY, 29. vii. 1846, on pine bushes, along the dugway woods; *5320-26, Salem, NY, 23. vii. 1847, on pine bushes, along the dugway woods; *5403-04, Salem, NY, 23. vii. 1847, on yellow oak, along the dugway woods; *6024, Salem, NY, 19. viii. 1847, on white oak, on Titus's hill; *6172, Salem, NY, 21. viii. 1847, on white pine, near McDougall's Lake; *6235-36; Salem, NY, 4. ix. 1847, on white oaks, northwest corner of mill lot.
Extant Specimens: *5322/ *Clastoptera testacea* Fitch/131 (MCZH); *6172/Fitch's Type/Fitch's Collection/*C. testacea* Fitch/Type No. 623 (USNM); 715 (NYSM); Female (NYSM); 716/Var. a (NYSM); 717/Var. b (NYSM); 718 (NYSM)).

Family DELPHACIDAE

99. **Delphax arvensis** Fitch, 1851a:46.
Delphacodes arvensis (Fitch).
Original Specimens:12,356-61, Salem, NY, 3. vi. 1847, in Jarvis Martin's wheat; *9506-07, Salem, NY, 9. vi. 1851, on flowers of *Potentilla*, west of Jarvis Martin's woods; *9981, Salem, NY, 21. vii. 1851, on grass and rushes, wet ground by creek; 2029, Tullehassie, AR, viii. 1851, from Wm. S. Robertson.
Extant Specimens:12,358/ *Delphax arvensis* Fitch/114 (MCZH); 622/Male (NYSM);623/Female (NYSM).

100. **Delphax dorsalis** Fitch, 1851a:46.
Stenocranus dorsalis (Fitch).
Original Specimens: *4253, Salem, NY, 2. ii. 1847, on melting snow, in the woods near McDougall's Lake; *8438, Salem, NY, 25. iv. 1851, on pools of water in meadow; *8500-02, Salem, NY, 26. vi. 1851, on the margin of a pool of water in the meadow, flying from the grass and walking on the water; *8550-53, Salem, NY, 29. iv. 1851, on the surface of pools of water in the meadow; *8575-82, Salem, NY, 29. iv. 1851, on sedge grass, beside pools of water in the meadow; *8672-78, Salem, NY, 7. v. 1851, on sedge grass beside pools of water in the meadow; *8759, Salem, NY, 10. v. 1851, on grass, marshy ground, Titus's hill; *9771-72, Hartford, NY, 27. vi. 1851, on grass about the big swamp; *10,309-311, Salem, NY, 20. xi. 1851, on snow, in the woods near McDougall's Lake; *10,312, Salem, NY, 21. xi. 1851, on snow, meadow below Jarvis Martin's.
Extant Specimens: *8500/ *Delphax dorsalis* Fitch/113 (MCZH); *8578/113A (MCZH); 621/Male (NYSM).

Family DERBIDAE

101. **Otiocerus amyotii** Fitch, 1857m:394.
Otiocerus amyotii Fitch.

Original Specimens:11,735, Stillwater, NY, 16. vii. 1846, on bitter walnut, southwest of grandmother's; 13,272, Stillwater, NY, vii. 1848, on walnut bushes, west of grandmother's; 1874, New Brunswick, NJ, 23. ix. 1851, on walnut bushes.

Extant Specimens:13,272/Fitch's Collection/Fitch's Type/ Type No. 588 (USNM).

102. **Anotia burnetii** Fitch, 1857m:395.
Anotia burnetii Fitch.
Original Specimens:Henderson River, IL, 2. x. 1854, beat from ash bushes by Albert Gallatin Burnet.
Extant Specimens:Illinois/Fitch's Collection/Fitch's Type/ Type No. 591 (USNM).

103. **Otiocerus kirbyii** Fitch, 1851a:46.
Otiocerus kirbyii Fitch.
Original Specimens:11,728, Stillwater, NY, 15-16. vii. 1846, on oak bushes, southwest of grandmother's; 11,734, Stillwater, NY, 15-16. vii. 1846, on bitter walnut, southwest of grandmother's; 11,737, Stillwater, NY, 15-16. vii. 1846, on *Viburnum lentago*, southwest of grandmother's; 11,738, Stillwater, NY, 16. vii. 1846, on oak bushes in big swamp.
Extant Specimens:Fitch's Collection/Fitch's Type/ 11,728/ Type No. 589 (USNM).
Note: Two specimens in the USNM collection bear Fitch's labels **8400 and **8401, and they are also labelled "Fitch's Type, Fitch's Collection." According to Fitch's specimen registers, these specimens were collected in 1858, and, therefore, they are not part of the original type series.

104. **Anotia robertsonii** Fitch, 1857m:395.
Anotia robertsonii Fitch.
Original Specimens:1750-51, Tullehassie, AR, vii. 1851, from Wm. S. Robertson.
Extant Specimens:1750/Fitch's Collection/Fitch's Type/ Type No. 592 (USNM); 1751/Fitch's Type/Fitch's Collection/ Type No. 592 (USNM).

105. **Otiocerus signoretii** Fitch, 1857m:394.
Otiocerus signoretti Fitch.
Original Specimens:2054, Tullehassie, AR, viii. 1851, from Wm. S. Robertson; 2150, Tullehassie, AR, x. 1851, on dogwood bushes, from Wm S. Robertson.
Extant Specimens:2054/Fitch's Collection/Fitch's Type/ Type No. 587 (USNM).

106. **Poeciloptera** *(?)* **vulgaris** Fitch, 1851a:47.
Cedusa vulgaris (Fitch).
Original Specimens: *5112, Stillwater, NY, 15. vii. 1847, beat from oak bushes; *5227, Salem, NY, 21. vii. 1847, on sugar maple, in Sidney Martin's meadow; *5272, Salem, NY, 21. vii. 1847, on thorn, in Sidney Martin's meadow.
Extant Specimens: *5112/Fitch's Type/Fitch's Collection/ Type No. 585 (USNM); *5227/Fitch's Type/Fitch's Collection/Type No. 585 (USNM); *5272/Fitch's Type/ Fitch's Collection/Type No. 585 (USNM); Fitch's Type/ Fitch's Collection/Type No. 585 (USNM, 2 specimens); 639/ Male (NYSM); 640/Female (NYSM).

107. **Anotia westwoodii** Fitch, 1857m:394.
Anotia westwoodii Fitch.
Original Specimens: *6300-03, Salem, NY, 10. ix. 1847, on willow bushes, Esq. Martin's meadow; *6500-01, Salem, NY, 11. ix. 1847, on willow bushes, Esq. Martin's meadow; 12,600-601, Salem, NY, 14. ix. 1850, on alder bushes, north side of big hill; **1959-63, Salem, NY, 3. viii. 1852, on grass, meadow south of Jarvis Martin's sawmill; *2203, Salem, NY, 20. viii. 1852, on *Solidago* weeds, Esq. Martin's meadow.
Extant Specimens: *6301/Fitch's Type/Fitch's Collection/ Type No. 590 (USNM); **1963/Fitch's Type/Fitch's Collection/Type No. 590 (USNM); **2203/Fitch's Type/ Fitch's Collection/Type No. 590 (USNM).

Family CIXIIDAE

108. **Cixius coloepeum** Fitch, 1857m:452.
Cixius coloepeum Fitch.
Original Specimens: *6850, Greenwich, NY, 6. vi. 1857, edge of woods north of P. C. Dunlap's.

109. **Cixius pini** Fitch, 1851a:45.
Cixius pini Fitch.
Original Specinmens: *2688, Salem, NY, 20. v. 1846, on pine trees, northwest corner of mill lot; 469-474, Winhall, VT, 17. vi. 1847, on spruce and fir trees, near summit of Green Mountains.
Extant Specimens:474/ *C. pini*/112 (MCZH); 616/Male (NYSM); 617/Female (NYSM).

Family ACHILIDAE

110. **Cixius cinctifrons** Fitch, 1857m:451.
Catonia cinctifrons (Fitch).
Original Specimens:1883, New Brunswick, NJ, 23. ix. 1851, on walnut bushes.

111. **Cixius impunctatus** Fitch, 1851a:46.
Catonia impunctata (Fitch).
Original Specimens:3964, Salem, NY, 22. viii. 1846, on oak bushes, on the ridge of Chester Martin's woodlot; *6031, Salem, NY, 19. viii. 1847, on black oak, Titus's hill; *6179, Salem, NY, 21. viii. 1847, on white pine, near McDougall's Lake.
Extant Specimens:618/Male (NYSM).

Family ISSIDAE

112. **Bruchomorpha dorsata** Fitch, 1857m:396.
Bruchomorpha dorsata Fitch.
Original Specimens:4480, Tullehassie, AR, vi. 1851; 1554-58, Tullehassie, AR, 1. vi. 1851, on grass, from Wm. S. Robertson; 2007-09, 3040-41, Tullehassie, AR, viii. 1851, from Wm. S. Robertson; 4802, Tullehassie, AR, 12. vi. 1852, from Wm. S. Robertson; 4467, Tullehassie, AR, 14. vi. 1852, from Wm. S. Robertson; 5103, Tullehassie, AR, 18. vi. 1852, from Wm. S. Robertson; 5337, Tullehassie, AR, 26. vi. 1852, on grass and bushes, from Wm. S. Robertson; 5444, Tullehassie, AR, 29. vi. 1852, from Wm. S. Rogertson; 5820, Tullehassie, AR, vii. 1852, from Wm. S. Robertson; 6206, Tullehassie, AR, 7. vii. 1852, from Wm. S. Robertson, 6400, Park Hill, AR, 30. viii. 1852, from Wm. S. Robertson, 6425-26, Tullehassie, AR, 30. viii. 1852, from Wm. S. Robertson; 6524, Tullehassie, AR, x. 1852, from Wm. S. Robertson; 10,184-185, Tullehassie, AR, 18. v. 1855, from Wm. S. Robertson.
Extant Specimens:1555/118 (MCZH).

113. **Naso robertsonii** Fitch, 1857m:396.
Fitchiella robertsonii (Fitch).
Original Specimens:1775-77, 4479, Tullehassie, AR, vii. 1851, from Wm. S. Robertson; 2010, Tullehassie, AR, viii. 1851, from Wm. S. Robertson; 5443, Tullehassie, AR, 29. vii. 1852, from Wm. S. Robertson; 6450 Tullehassie, AR, x. 1852, from Wm. S. Robertson; 8920, near Keithsburg, IL, 9. x. 1854, swept from grass among timber by Albert Burnett, near Mr. Kimball's.
Extant Specimens:1776/ *Naso robertsonii*/119 (MCZH).

Family PSYLLIDAE

114. **Psylla annulata** Fitch, 1851a:64.
Psylla annulata Fitch.
Original Specimens: *5220-24, Salem, NY, 21. vii. 1847, on sugar maple, border of Esq. Martin's meadow; 13,303-306, Stillwater, NY, vii. 1848?, on oak bushes, west of grandmother's; *9681-82, Salem, NY, 17. vi. 1851, on bushes near McDougall's Lake.
Extant Specimens: *5221/Type No. 1366 (USNM); 13,306 (USNM); *9681/Type No. 1366 (USNM); *9682/Type No. 1366 (USNM).

115. **Diraphia calamorum** Fitch, 1858e:740.
Livia vernalis Fitch.
Original Specimens:7800, New Brunswick, NJ, 15. v. 1854, on *Acorus calamus*, beside Raritan River, two miles below the city.
Extant Specimens:7800/Type No. 1367 (USNM).
Note: A specimens in the USNM collection bears Fitch's label, 15,246, and it is also labelled "Type No. 1367." According to Fitch's specimen registers, this specimen was collected in 1862, and, therefore, it is not part of the original type series.

116. **Psylla carpini** Fitch, 1851a:64.
Psylla carpinicola Crawford.
Original Specimens: *3171, Salem, NY, 3. vii. 1846, on *Carpinus*, in Harvey's meadow; *3640, Salem, NY, 24. vii. 1846, beat from bushes, Jarvis Martin's woods; *3680-85, Salem, NY, 27. vii. 1846, on *Carpinus*, beside the hill in Esq. Martin's meadow; *9219-33, Salem, NY, 30. v. 1851, on *Carpinus*, willows, and weeds, Esq. Martin's meadow; *9680, Salem, NY, 17. vi. 1851, on leaves of bushes by McDougall's Lake.
Extant Specimens: *3640/203 (MCZH); *3681/Type No. 1343 (USNM); *9233/Type No. 1343 (USNM); *9680/Type No. 1343 (USNM).

117. **Livia femoralia** Fitch, 1851a:64.
Livia vernalis Fitch.
Original Specimens:11,875, Salem, NY, 29. vii. 1846, on pine leaves, on top of the dugway hill.
Extant Specimens:Female/838 (USNM).
Note: The number 838 on the above specimen is written in Fitch's handwriting, and it corresponds with the specimen number given in his original description. This specimen is listed as "destroyed" in McCabe and Johnson (*Bull. N. Y. State Museum* 434, 1980).

118. **Chermes laricifoliae** Fitch, 1858e:752.
Original Specimens: *9974-75, Salem, NY, 14. vii. 1851, solitary, on tamarack leaves in the back yard.

119. **Diraphia maculipennis** Fitch, 1858e:740.
Livia maculipennis (Fitch).
Original Specimens:7801-02, New Brunswick, NJ, 15. v. 1854, on *Acorus calamus* growing in vast tracts, beside the Raritan River two miles below the city.
Extant Specimens:7801/7802/Type No. 1344 (USNM, 2 specimens on same pin).

120. **Psylla quadrilineata** Fitch, 1851a:64.
Psylla quadrilineata Fitch.
Original Specimens: *4263, Salem, NY, 4. iii. 1847, on snow, near McDougall's Lake; *8636-38, Salem, NY, 7. v. 1851, on willow in the meadow; *8819-23, Salem, NY, 10. v. 1851, on willow in Esq. Martin's meadow.
Extant Specimens: *8636/Type No. 1342 (USNM); *8637/Type No. 1342 (USNM).
Note: A specimen in the USNM collection bears Fitch's label *8825, and it is also labelled "Type No. 1342." According to Fitch's manuscript notes and specimen registers, he did not consider this specimen to be *P. quadrilineata*, so it cannot be considered a type of this species.

121. **Psylla tripunctata** Fitch, 1851a:64.
Trioza tripunctata (Fitch).
Original Specimens: **350-351, Salem, NY, 28. xi. 1851, on snow, in the wood lot.
Extant Specimens: **350/**351/Type No. 1345 (USNM, two specimens on same pin).

122. **Livia vernalis** Fitch, 1851a:64.
Livia vernalis Fitch.
Original Specimens: *2001-04, Salem, NY, 6. iv. 1846, on the big hill, in sap of the sugar maple; *5341, Salem, NY, 23. vii. 1847, beat from pine leaves, dugway hill; *7294, Salem, NY, 12. v. 1848, on black currant bushes in the meadow; *9896, Salem, NY, 9. vi. 1851, on grass, west border of Jarvis Martin's woods; **5870-73, Salem, NY, 24. ix. 1851, on leaves of pine bushes, Titus's hill.
Extant Specimens: **5870/Type No. 1341 (USNM); **5871/Type No. 1341 (USNM); **5872/Type No. 1341 (USNM); **5873/Type No. 1341 (USNM); Male/836 (USNM).
Note: The number 836 on the above specimen is written in Fitch's handwriting, and it corresponds with the specimen number given in his original description. This specimen is listed as "destroyed" in McCabe and Johnson (*Bull. N. Y. State Museum* 434, 1980).

Family ALEYRODIDAE

123. **Aspidiotus gossypii** Fitch, 1857m:332.
Aleyrodes gossypii (Fitch).
Original Specimens: "Upon the leaves of a dried specimen of the China cotton plant (*Gossypium religiosum*) sent me from Ningpo by Rev. M. S. Culbertson. . . ."

Family APHIDIDAE

124. **Lachnus abietis** Fitch, 1851a:67.
Cinara abietis (Fitch).
Original Specimens:346-47, Stratton, VT, 17. vi. 1847, beat from spruce bushes.

125. **Lachnus alnifoliae** Fitch, 1851a:67.
Pterocallis alnifoliae (Fitch).
Original Specimens:12,003-004, Salem, NY, 25. viii. 1846, on alder leaves near the former junction of the creeks in the meadow.

126. **Aphis asclepiadis** Fitch, 1851a:65.
Aphis asclepiadis Fitch.
Original Specimens: *4500-11, Salem, NY, 25. vi. 1847, on milkweed, back of Josephus Martin's barn, on the young leaves near the top of the stalk, in dense colonies.
Extant Specimens: *4504/From Fitch Collection/ *Aphis asclepiadis* Fitch/ 9175 (USNM); *4505/From Fitch Collection/ *Aphis asclepiadis* / 9175 (USNM); *4507 / From Fitch Collection/ *Aphis asclepiadis*/9175 (USNM); From Fitch Collection/ *Aphis asclepiadis* Fitch/9175 (USNM).

127. **Aphis berberidis** Fitch, 1851a:65.
Liosomaphis berberidis (Kaltenbach).
Original Specimens: *4201-02, Salem, NY, xi. 1846, on barberry in back yard; *9143-48, Salem, NY, 28. v. 1851, on barberry in back yard.
Extant Specimens: 842/ Male (NYSM); 843/Female (NYSM).
Note: Eleven specimens in the USNM collection are labelled "*Liosomaphis berberidis*, Fitch (Type)." Eight of them lack Fitch's specimen numbers, but the remaining three bear his labels **1130, **1131, and **1133. According to Fitch's specimen registers, these three specimens were collected in 1854, and, therefore, they are not part of the original type series.

128. **Aphis betulaecolens** Fitch, 1851a:66.
Calaphis betulaecolens (Fitch).
Original Specimens:465, Winhall, VT, 17. vi. 1847, near summit of the Green Mountains, on *Viburnum lantanoides* or *acerifolium*; *4860-61, *4937-38, Salem, NY, 5. vii. 1847, on birch, bank of the kill, Esq. Martin's pasture.
Extant Specimens:6807, (*Aphis*) *betulaecolens*, Fitch (848, Cotype), from Fitch Collection/Remt'd Quednau '70/848/ Birch-inhabiting *Aphis*, *A. betulaecolens*, Fh. (USNM).
Note: The number 848 on the above specimen is written in Fitch's handwriting, and it corresponds with the specimen number given in his original description. This specimen is listed as "destroyed" in McCabe and Johnson (*Bull. N. Y. State Museum* 434, 1980).

129. **Aphis mali bivincta** Fitch, 1855n:760.
Original Specimens: **4992, Salem, NY, 31. x. 1854.
Extant Specimens:9747, *Aphis mali*, var. *bivincta* Fitch, Fitch No. 4992, Mounted by Pergande, Type, A.C.B./*A. mali bivincta*/**4992 (USNM).

130. **Eriosoma caryae** Fitch, 1857m:443.
Prociphilus caryae (Fitch).
Original Specimens:8377, north of Henderson River, IL, 2. x. 1854, on walnut bushes.
Extant Specimens:920, P, Type, from old Fitch Collection/ 8377/Illinois (USNM).

131. **Aphis caryella** Fitch, 1855n:867.
Monellia caryella (Fitch).
Original Specimens: *4735, Salem, NY, 28. vi. 1847, on walnut leaves, border of Jarvis Martin's woods; **1539-49, Salem, NY, 21. vi. 1852, on walnut leaves above red bridge; **1793-94, Salem, NY, 8. vii. 1852, south base of Battle Hill.
Extant Specimens: **1539/Cotype (USNM); **1540/Type (USNM); **1541/Type (USNM); **1542/Cotype (USNM); **1543/Type (USNM).

132. **Callipterus castaneae** Fitch, 1857m:471.
Calaphis castaneae (Fitch).
Original Specimens: *4882-87, Salem, NY, 31. viii. 1854, on underside of leaves of chestnut.

133. **Aphis cerasicolens** Fitch, 1851a:65.
Euceraphis betulae (Koch).
Original Specimens: *5658-61, Salem, NY, 8. viii. 1847, on black cherry tree, in Esq. Martin's pasture.
Extant Specimens:Cotype, From Fitch Collection/841/ Cherry-inhabiting *Aphis*, *A. cerasicolens*, Fh. (USNM).
Note: The number 841 on the above specimen is written in Fitch's handwriting, and it corresponds with the specimen number given in his original description. This specimen is listed as "destroyed" in McCabe and Johnson (*Bull. N. Y. State Museum* 434, 1980).

134. **Aphis cerasifoliae** Fitch, 1855n:835.
Rhopalosiphum cerasifoliae (Fitch).
Original Specimens:13. vii. 1855, 31. viii. 1855, undersides of young, tender, apical leaves of chokecherry, beside the railroad in Alexander's (formerly Judge Savage's) meadow.
Extant Specimens:*Aphis cerasifoliae*, type from the Fitch collection, mounted – Pergande (USNM).

135. **Aphis circezandis** Fitch, 1871:501.
Aphis gossypii Glover.
Original Specimens: **1319-23, Salem, NY, 11. vi. 1852, on *Galium circezans*, dugway woods.
Extant Specimens:*Aphis circezandis* (Type)/**1319 (USNM); *Aphis circezandis* (Type)/**1320 (USNM); *Aphis circezandis* (Type)/**1321 (USNM); *Aphis circezandis* (Type)/ **1322 (USNM).

136. **Aphis cornifoliae** Fitch, 1851a:65.
Aphis cornifoliae Fitch.
Original Specimens: *5408-09, Salem, NY, 27. vii. 1847, on *Cornus paniculata*, Esq. Martin's meadow.
Extant Specimens:846 Fitch (Type)/Female/Dogwood-leaf *Aphis*, *A. cornifoliae*, Fh. (USNM); *Aphis cornifoliae*, Fitch (Type) on *Cornus paniculata*, New York (USNM).
Note: The number 846 on the above specimen corresponds with the specimen number given in Fitch's original description. This specimen is listed as "destroyed" in McCabe and Johnson (*Bull. N. Y. State Museum* 434, 1980).

137. **Aphis caryella costalis** Fitch, 1855n:869.
Monellia costalis (Fitch).
Original Specimens: **1794, Salem, NY, 8. vii. 1852, on walnut leaves, south base of battle hill.
Extant Specimens:Mounted from the Fitch Coll. by A. C. Baker/**1794/Type (USNM).

138. **Aphis crataegilfoliae** Fitch, 1851a:66.
Nearctaphis crataegifoliae (Fitch).
Original Specimens:12,319-326, Salem, NY, 3. vi. 1847, common on a bush of *Crataegus punctata* growing in back

yard; *9283-91, Salem, NY, 2. vi. 1851, upon a shrub of *Crataegus coccinea* growing in the edge of the meadow.
Extant Specimens: *9287/*Aphis crataegifoliae* Fitch, N.Y./ 206 (MCZH); *Aphis crataegifoliae* Type 9130 (USNM).

139. **Aphis mali fulviventris** Fitch, 1855n:760.
Original Specimens: **5000, Salem, NY, 31. x. 1854.
Extant Specimens: **5000/ *A. mali fulviventris*/mounted by Pergande/Type (USNM).

140. **Aphis fumipennella** Fitch, 1855n:870.
Myzocallis fumipennella (Fitch).
Original Specimens: **1791-92, Salem, NY, 8. vii. 1852, beat from walnut bushes, south base of Battle Hill.
Extant Specimens: *1791 (Type) (USNM).

141. **Brysocrypta hamamelidis** Fitch, 1851a:69.
Hormaphis hamamelidis (Fitch).
Original Specimens: *6194-98, Salem, NY, 21. viii. 1847, near McDougall's Lake; *9683-84, Salem, NY, 7. vi. 1851, at outlet of McDougall's Lake.
Extant Specimens: 869/ Male (NYSM); 870/ Larva (NYSM); 871/Follicle (NYSM).

142. **Eriosoma imbricator** Fitch, 1851a:68.
Fagiphagus imbricator (Fitch).
Original Specimens:11,979-986, Salem, NY, 22. viii. 1846, woods near McDougall's Lake, on beech twigs and leaves.
Extant Specimens: 864/ Male (NYSM); 865/ Female? (NYSM); 866/Larva (NYSM).

143. **Aphis mali immaculata** Fitch, 1855n:760.

144. **Rhizobius lactucae** Fitch, 1872a:360.
Pemphigus bursarius (Linnaeus).
Extant Specimens:*Rhizobius lactucae*, Fitch (Fitch's label)/ Fitch's type mount'd from the Fitch Coll. by Theo. Perg., A. C. B. (USNM).

145. **Lachnus laricifex** Fitch, 1858e:752.
Cinara laricifex (Fitch).
Original Specimens: **930-939, Salem, NY, 17. v. 1852, on tamarack (drooping) in front yard.

146. **Aphis maculella** Fitch, 1855n:870.
Monellia maculella (Fitch).
Original Specimens: **1539, Salem, NY, 21. vi. 1852, on walnut leaves above the red bridge.

147. **Aphis maidis** Fitch, 1856l:550.
Rhopalosiphum maidis (Fitch).
Original Specimens: **375-378, Salem, NY, viii. 1851, gregarious, in a large colony, on the inner side of the pistillate peduncles of the Indian corn; Salem, NY, 20. ix. 1855, on peduncle of corn beside office.

148. **Aphis malifoliae** Fitch, 1855n:760.
Nearctaphis crataegifoliae (Fitch).
Original Specimens:Keithsburgh, IL, 4. x. 1854, beat from apple trees, A. Burnett's.

149. **Aphis marginella** Fitch, 1855n:870.
Monellia costalis (Fitch).
Original Specimens: Salem, NY, 8.ix.1855, from pupa on walnut leaves, hatched in office.

150. **Callipterus mucidus** Fitch, 1857m:334.
Euceraphis mucida (Fitch).
Original Specimens: Salem, NY, 5.vi.1856, beat from apple tree in back yard; Salem, NY, 10.vi.1856, flying among bushes in woods by outlet of McDougall's Lake.
Extant Specimens: *Callipterus mucidus*, Fitch, on apple, Type 9315 (USNM, 2 specimens).

151. **Aphis mali nigricollis** Fitch, 1855n:760.
Original Specimens: **4993, Salem, NY, 31.x.1854.
Extant Specimens: 9747. *Aphis mali* var.*nigricollis* Fitch, Fitch No.4993, Mounted by Pergande, Type, A.C.B./ **4993 (USNM).

152. **Aphis mali nigriventris** Fitch, 1855n:760.
Original Specimens: **4997, Salem, NY, 31.x.1854.
Extant Specimens: 9747. *Aphis mali* var.*nigriventris* Fitch, Fitch No.4997, mounted by Pergande, Type, A.C.B./ **4997 (USNM).

153. **Aphis mali obsoleta** Fitch, 1855n:760.
Original Specimens: *4990, Salem, NY, 31.x.1854.
Extant Specimens: 9747. *Aphis mali* var.*obsoleta* Fitch, Fitch No.4990, Mounted by Pergande, Type, A.C.B./ **4990 (USNM).

154. **Aphis mali pallidicornis** Fitch, 1855n:759.
Original Specimens: **4987, Salem, NY, 31.x.1854.
Extant Specinmens: 9747. *Aphis mali pallidicornis* Fitch, Fitch No.4987. Mounted by Pergande. Type, A.C.B./ **4987 (USNM).

155. **Aphis pinicolens** Fitch, 1851a:66.
Euceraphis pinicolens (Fitch).
Original Specimens: *4919, Salem, NY, 5.vii.1847, at rest on a white pine bush in the pine woods.
Extant Specimens: 9391, *A.pinicolens*, Fitch. (842) (Cotype) From Fitch Collection/842/Pine-inhabiting *Aphis* (USNM).
Note: According to Fitch's Homoptera catalog, specimen 842 is *Aphis berberidis*.

156. **Pemphigus popularia** Fitch, 1859d:849.
Pemphigus popularius Fitch.
Original Specimens: Salem, NY, 12.x.1855, numerous specimens walking down and up the trunk of the Balm of Gilead in the front yard, and some on the leaves with a species of *Aphis* ....Save 11 specimens.

157. **Pemphigus populicaulis** Fitch, 1859d:845.
Pemphigus populicaulis Fitch.
Original Specimens: Salem, NY, 27.vi.1856, from galls, Lombard poplar, front yard.

158. **Aphis populifoliae** Fitch, 1851a:66.
Pterocomma populifoliae (Fitch).
Original Specimens: *6118-22, Salem, NY, 19.viii.1847, east of Mrs.Fitch's woods, on *Populus grandidentata*; *9292-9302, Salem, NY, 5.vi.1851, on *Populus grandidentata* twigs, in edge of meadow.
Extant Specimens: 9171, (Type), F. No.9292/*9292 (USNM); 9171, on *Populus grandidentata* (9293, Cotype), from Fitch Collection/ *9293 (USNM); *9294/*Aphis populifoliae* Fitch/208 (MCZH); 9171, (Type), Fitch 9297/*9297 (USNM); 9171, (nymph from apterous type), F9297/*9297

(USNM); *9298/208A (MCZH): 9171 (Type) F. No.9300/ *9300 (USNM); 9171 (Type), Fitch 9301/*9301 (USNM); 9171, (*Aphis*) *populifoliae*, Fitch, on *Populus grandidentata* (Cotypes), from Fitch Collection/Poplar-leaf *Aphis*, *A.populifoliae*, Fh.(USNM).

159. **Pemphigus populiglobuli** Fitch, 1859d:850.
Pemphigus populiglobuli Fitch.
Original Specimens: Salem, NY, 15.vii.1859, in galls on Balsam poplar leaves, from yard.
Extant Specimens: *P.populiglobuli* Fitch, Type, Mounted from Fitch coll.by A.C.Baker (USNM).

160. **Pemphigus populivenae** Fitch, 1859d:851.
Pemphigus populivenae Fitch.
Original Specimens: Salem, NY, 23.vii.1856, in galls on Balsam poplar leaves, in front yard; Salem, NY, 15.vii.1859, in galls on Balsam poplar leaves, in front yard.
Extant Specimens: *P.populivenae* Fitch. Mounted from the Fitch Coll.by A.C.Baker, Type (USNM).

161. **Aphis prunifoliae** Fitch, 1855n:826.
Rhopalosiphum padi (Linnaeus).
Original Specimens: **3772-83, Greenwich, NY, 29.v.1854, on plum trees (**3780-82, variety c; *3778, *3781, variety d; *3776, variety e; *3773, variety f; *3775, variety g).
Extant Specimens: 9752, (Type)/*Aphis prunifoliae*, Fitch/a (USNM); 9752 (Aphis) *prunifoliae*, Fitch (Type), Fitch d/d (USNM); 9752, (*Aphis*) *prunifoliae*, Fitch (Type), Fitch (e)/e (USNM); 9752, (*Aphis*) *prunifoliae*, Fitch (Type), Fitch (f)/f (USNM); 9752, (*Aphis*) *prunifoliae*, Fitch (Type)/g (USNM).

162. **Aphis punctatella** Fitch, 1855n:869.
Myzocallis punctatella (Fitch).
Original Specimens: **1537-38, Salem, NY, 21.vi.1852, on walnut leaves, above the red bridge.
Extant Specimens: 1537, Fitch, on hickory (Type), Fitch No.1537, **1537 (USNM).

163. **Eriosoma pyri** Fitch, 1851a:68.
Prociphilus caryae fitchii Baker and Davidson.
Original Specimens: *4053-54, Salem, NY, 10.xi.1846; 13,254-258, Glens Falls, NY, 29.x.1849, on apple-tree roots, from nursery.
Extant Specimens: *4053, Eriosoma pyri Fitch/218 (MCZH); *4054/218A (MCZH); (F 13,255) (Type)/13,255 (USNM); (Type), (Fitch) collection (USNM); Male (NYSM); 862 (NYSM).

164. **Eriosoma querci** Fitch, 1859d:804.
Anoecia querci (Fitch).
Original Specimens: 7946-49, Ottawa, IL, 16.x.1854, beat from oaks, south of Covill Creek; 7950-51, Ottawa, IL, 16.x.1854, swept from grass, south of Covill Creek.
Extant Specimens: Type!, from Fitch Collection (No.7948) (of Fitch)/2912 (USNM); Mounted from the Fitch Collection by A.C.Baker, Fitch No.7949, *querci* – Cotype (USNM); Mounted from the Fitch Collection by A.C.Baker, Fitch No.7950, *querci* – Cotype (USNM); Mounted from the Fitch Collection by A.C.Baker, Fitch No.7951, *querci* – Cotype (USNM).

165. **Lachnus quercifoliae** Fitch, 1851a:67.
Chaitophorus quercifoliae (Fitch).
Original Specimens: *4841-42, *4935-36, Salem, NY, 5.vii.1847, on a white oak tree, in Esq.Martin's pasture.

166. **Byrosocrypta rhois** Fitch, 1866f:73.
Melaphis rhois (Fitch).
Original Specimens: Salem, NY, 8.vii.1854, on young sumach in front yard.

167. **Aphis rudbeckiae** Fitch, 1851a:66.
Dactynotus rudbeckiae (Fitch).
Original Specimens: 11,715-720, Salem, NY, 13.vii.1846, on *Solidago serotina*, *S.gigantea*, and *S.altissima* growing in the meadow; 12,676-679, Salem, NY, viii.1850, on stalks of *Rudbeckia laciniata*.
Extant Specimens: 11,715, *Aphis rudbeckiae* Fitch/207 (MCZH); 11,717/207A (MCZH); Male (NYSM); 853 (NYSM).
Note: Four specimens in the USNM collection bear Fitch's labels **4282-85, and they are also labelled "Type." According to Fitch's specimen registers, these specimens were collected in 1854, and, therefore, they are not part of the original type series.

168. **Lachnus salicellis** Fitch, 1851a:67.
Chaitophorus salicellis (Fitch).
Original Specimens: 11,721-724, Salem, NY, 13.vii.1846, from the willow tree supporting the foot- bridge over White Creek.
Extant Specimens: 9392, (*Lachnus*) *salicellis*, Fitch (856), Cotype, From Fitch Collection/958/Willow *Lachnus* (USNM).

169. **Aphis sambucifoliae** Fitch, 1851a:66.
Aphis sambuci Linnaeus.
Original Specimens: *5085-86, Saratoga Springs, NY, 15.vii.1847, on the underside of leaves of the elder (?).
Extant Specimens: 9395, *Aphis sambucifoliae* Fitch (850; Cotype), From Fitch Collection/850/Elder-leaf *Aphis* (USNM).
Note: The number 850 on the above specimen corresponds with the specimen number given in Fitch's original description. This specimen is listed as "destroyed" in McCabe and Johnson (*Bull. N. Y. State Museum* 434, 1980).

170. **Eriosoma strobi** Fitch, 1851a:69.
Cinara strobi (Fitch).
Original Specimens: *3094-96, Salem, NY, 24.vi.1846, on white pine on big hill; *4862, Salem, NY, 5.vii.1847, bank of the kill, on birch tree, where it had probably come from an adjoining much infested pine.
Extant Specimens: *Cinara strobi* (Fitch), Det.Feb. 1966/by Pepper and Tissot, Accepted as type of *strobi* (Fitch) (USNM); *Eriosoma strobi* Fitch, Metatype, Mounted from the Fitch coll.by Pergande, A.C.B./Pine-tree blight (USNM).

171. **Aphis mali tergata** Fitch, 1855n:760.
Original Specimens: **4994, Salem, NY, 31.ix.1854.
Extant Specimens: 9747, *Aphis mali* var.*tergata* Fitch, Fitch No.4994, mounted by Pergande, Type, A.C.B./**4994 (USNM).

172. **Eriosoma tessellata** Fitch, 1851a:68.
Prociphilus tessellatus (Fitch).
Original Specimens: 12,001-002, Salem, NY, 25.viii.1846, from alders where Black and White Creeks formerly united in the meadow.
Extant Specimens: 863 (NYSM); Female?(NYSM).

173. **Aphis mali thoracica** Fitch, 1855n:760.
Original Specimens: **4995, Salem, NY, 31.x.1854.
Extant Specimens: 9749, *Aphis mali* var. *thoracica* Fitch, Fitch No.4995, Mounted by Pergande, Type, A.C.B./ **4995 (USNM).

174. **Aphis mali triseriata** Fitch, 1855n:760.
Original Specimens: **4988, Salem, NY, 31.x.1854.
Extant Specimens: 9747, *Aphis mali* var. *triseriata* Fitch, F. No.4988, Mounted by Pergande, Type, A.C.B./ **4988 (USNM).

175. **Byrsocrypta ulmicola** Fitch, 1859d:843.
Colopha ulmicola (Fitch).
Original Specimens **9687-88, Salem, NY, 17.vi.1851, near outlet of McDougall's Lake; Salem, NY, 20.vii.1859, dead, gall, on elm leaf in front yard.

Family ADELGIDAE

176. **Coccus pinicorticis** Fitch, 1855n:871.
Pineus strobus (Hartig).
Original Specimens: Fort Miller, NY, 1852, on young pines, in John Pattison's yard; Salem, NY, 13.xi.1854, on the young pine, south side of my house.

177. **Chermes pinifoliae** Fitch, 1858e:741.
Pineus pinifoliae (Fitch).
Original Specimens: **946-48, Salem, NY, 16.v.1852, on white pine, in the front yard; **940-945, Salem, NY, 22.v.1852, on white pine, in the front yard.

Family PHYLLOXERIDAE

178. **Pemphigus caryaecaulis** Fitch, 1855n:859.
Phylloxera caryaecaulis (Fitch).

179. **Phylloxera caryaefoliae** Fitch, 1857m:446.
Paramoritziella caryaefoliae (Fitch).
Original Specimens: **1520-32, Salem, NY, 21.vi.1852, on walnut leaves above red bridge.

180. **Pemphigus(?) caryaevenae** Fitch, 1857m:444.
Phylloxera caryaevenae (Fitch).
Original Specimens: 2.ix.1855, in hickory leaves, plaits formed by a louse.

181. **Pemphigus vitifoliae** Fitch, 1855n:862.
Daktulosphaira vitifoliae (Fitch).
Original Specimens: 11.vi.1855, in small red and yellow galls scarcely the size of a pea, on the margin of leaves of the grapevine.

Family DIASPIDIDAE

182. **Aspidiotus cerasi** Fitch, 1857m:368.
Chionaspis furfura (Fitch).
Original Specimens: 14.ii.1857, on limbs of chokecherry bushes.
Extant Specimens: Cherry scale insect, *Aspidiotus cerasi*/ Coll.N.Y.State Agric.Soc.(NYSM).

183. **Aspidiotus circularis** Fitch, 1857m:426.
Original Specimens: 14,221, Albany, NY, 14.iv.1856, on currant in Mr.Orcutt's garden.
Extant Specimens: *A.circularis*, Fitch MSS, (Type) (USNM).

184. **Aspidiotus furfurus** Fitch, 1857m:352.
Chionaspis furfura (Fitch).
Original Specimens: *1915-18, Jacksonville, IL, from Prof. B.Turner, pr.B.P.Johnson; *1919-21, Jacksonville, IL, from Prof.B.Turner (showing scurf on bark); *1922-26, Jacksonville, IL, from Prof.B.Turner, pr.J.J.Thomas.
Extant Specimens: Scurfy Bark Louse, *Aspidiotus furfurus*/Coll.N.Y.State Agric.Soc.(NYSM).

185. **Aspidiotus juglandis** Fitch, 1855n:739.
Lepidosaphes ulmi (Linnaeus).
Original Specimens: Salem, NY, 31.v.1854, on a butternut twig, Chester Martin's meadow.

186. **Aspidiotus pinifoliae** Fitch, 1856l:488.
Phenacaspis pinifoliae (Fitch).
Original Specimens: *450-53, Springfield, IL, 5.ix.1855, from Robert W.Kennicott, leaves of his white pines.
Extant Specimens: Pine-leaf Scale-insect, *Aspidiotus pinifoliae*, Coll.N.Y.State Agric.Soc.(NYSM).

Family COCCIDAE

187. **Lecanium acericorticis** Fitch, 1860o:22.
Pulvinaria vitis (Linnaeus).
Original Specimens: **3786, Salem, NY, 1.vi.1854, on a maple, west border of Jarvis Martin's woods; 15.v.1855, twenty specimens taken from a maple twig.

188. **Lecanium caryae** Fitch, 1857m:443.
Eulecanium caryae (Fitch).
Original Specimens: *3723-37, Salem, NY, 1.vi.1854, from twigs of a walnut, west side of Jarvis Martin's woods.
Extant Specimens: *Lecanium caryae*, Fitch/**3735 (USNM); Hickory Scale-insect, and its chalk-mark on the bark, *Lecanium caryae*/Coll.N.Y.State Agric.Soc.(NYSM).

189. **Lecanium cerasifex** Fitch, 1857m:368.
Parthenolecanium cerasifex (Fitch).
Original Specimens: **4126, Salem, NY, 12.vi.1854, on a small limb of the wild black cherry.
Extant Specimens: *Lecanium cerasifex*, Fh./**4126 (USNM).

190. **Lecanium corylifex** Fitch, 1857m:473.
Parthenolecanium corni (Bouché).
Original Specimens: **1449, **1452, **1459, **1461-62, **1465-69, **1475, Salem, NY, 31.v.1854, on underside of hazelnut twigs, Chester Martin's meadow.
Extant Specimens: On Hazel (*Corylus*), Salem, N.Y., Dr.A.Fitch, May 31, 1854, Fitch Coll., Type (USNM).

191. **Lecanium cynosbati** Fitch, 1857m:436.
Parthenolecanium corni (Bouché).

Original Specimens: **1824, Salem, NY, 1.vi.1854, upon a small bunch of wild gooseberry, growing by the brook, west of Jarvis Martin's woods.

Extant Specimens: On Gooseberry, Salem, N.Y.(#1824), June 1, 1854, Fitch Coll., Type (USNM).

192. **Lecanium juglandifex** Fitch, 1857m:463.
Parthenolecanium corni (Bouché).
Original Specimens: **1476-80, Salem, NY, 31.v.1854, from a butternut in Chester Martin's meadow; **3883-90, **3896, Salem, NY, 7.vi.1854, on butternut.

193. **Lecanium quercifex** Fitch, 1859d:805.
Parthenolecanium quercifex (Fitch).
Original Specimens: *3784-85, Salem, NY, 29.vii.1846, on white oak leaves, on dugway hill; **3738-42, Salem, NY, 1.vi.1854, from a young white oak, northwest corner of mill lot.
Extant Specimens: White-oak Scale-insect/Coll.N.Y. State Agric.Soc.(NYSM).

194. **Lecanium quercitronis** Fitch, 1859d:805.
Parthenolecanium quercifex (Fitch).
Original Specimens: **3743-69, Salem, NY, 1.vi.1854, on black oak along west margin of Jarvis Martin's woods.
Extant Specimens: Quercitron Scale-insect, *Lecanium quercitronis*/Coll.N.Y. State Agric.Soc.(NYSM).

195. **Lecanium ribis** Fitch, 1857m:427.
Parthenolecanium corni (Bouché).
Original Specimens: Albany, NY, 14.iv.1856, currant bushes in Mr.Orcutt's garden.

196. **Coccus salicis** Fitch, 1851a:69.
Pulvinaria vitis (Linnaeus).
Original Specimens: *3376-77, Salem, NY, 13.vii.1846, at the footbridge.
Extant Specimens: 873/Coll.N.Y.State Agric. Soc. (NYSM).

197. **Coccus tiliae** Fitch, 1851a:69.
Parthenolecanium corni (Bouché).
Original Specimens: *3378-79, Salem, NY, 13.vii.1846, near the footbridge in the meadow.

Family ANTHOCORIDAE

198. **Anthocoris pseudochinche** Fitch, 1856l:527.
Triphleps insidiosa (Say).
Original Specimens: 8395, Keithsburg, IL, 2.x.1854, on ash bushes, beside north side of Henderson River; 8434, Keithsburg, IL, 2.x.1854, on aster flowers, north side of Henderson River; 10,230, Geneva, WI, 9.vii.1855, from Mr.Williams.
Extant Specimens: 10,230/8434/8395/Type No.1139, USNM/*Anthicoris pseudochinche*, Wisconsin (USNM, 3 specimens on one pin).

199. **Anthocoris pseudochinche semiclarus** Fitch, 1856l:527.
Original Specimens: 8394, Keithsburg, IL, 2.x.1854, on ash bushes, north side of Henderson River; 8952, IL, 9.x.1854, on burr oaks by Pope's River.

Family TINGIDAE

200. **Tingis cydoniae** Fitch, 1861o:114.
Corythucha cydoniae (Fitch).
Extant Specimens: Fitch's Collection/*Tingis cydoniae*, Fh.(USNM).

201. **Tingis juglandis** Fitch, 1857m:466.
Corythucha juglandis (Fitch).
Original Specimens: 5600-03, Stillwater, NY, 28.vi.1836, along Schuyler's Brook on butternut bushes; 10,208-212, Salem, NY, 16.v.1845, on *Veratrum* leaves, Josephus Martin's meadow; *2851, Granville, NY, 11.vi.1846, on black birch; *2980-81, Jackson, NY, 16.vi.1846, on white birch, beside the kill; *3002, Salem, NY, vi.1846; *3188-89, Salem, NY, 3.vii.1846, in Harvey's meadow, on the butternut; 11,900, *3861, Salem, NY, 6.viii.1846, on basswood near footbridge in the meadow; *4010-11, Greenwich, NY, 24.viii.1846, on butternut, near P.C.Dunlap's; 12,480-481, Dresden, NY, 10.vi.1847, near the summit of Black Mountain; *5246, Salem, NY, 21.vii.1847, on sumach, Sidney Martin's meadow; *5595, Salem, NY, 29.vii.1847, on *Cornus paniculata*, north side of Black Creek; *6332-33, Salem, NY, 10.ix.1847, on willows in Esq.Martin's meadow; *6980-84, Long Island, NY, 1847, from Wm.S.Robertson, *9248-49, Salem, NY, 30.v.1851, on weeds, Esq.Martin's meadow; **1224-26, Salem, NY, 26.v.1852, on butternut, Esq.Martin's meadow; **1482-84, Salem, NY, 21.v.1854, on butternut, Chester Martin's meadow; 9241, IL, 6.x.1854, on grapevine, along Henderson River.
Extant Specimens: **1224/Fitch's Type/**1226/*Tingis juglandis*, Fitch/Type No.1020 (USNM, 2 specimens on one pin).

Family LYGAEIDAE

202. **Micropus leucopterus albivenosus** Fitch, 1856l:523.
Blissus leucopterus albivenosus (Fitch).

203. **Micropus leucopterus apterus** Fitch, 1856l:523.
Blissus leucopterus apterus (Fitch).

204. **Micropus leucopterus basalis** Fitch, 1856l:523.
Blissus leucopterus basalis (Fitch).

205. **Micropus leucopterus dimidiatus** Fitch, 1856l:523.
Blissus leucopterus dimidiatus (Fitch).

206. **Micropus leucopterus femoratus** Fitch, 1856l:523.
Blissus leucopterus femoratus (Fitch).

207. **Micropus leucopterus fulvivenosus** Fitch, 1856l:523.
Blissus leucopterus fulvivenosus (Fitch).

208. **Micropus leucopterus immarginatus** Fitch, 1856l:522.
Blissus leucopterus immarginatus (Fitch).

209. **Micropus leucopterus nigricornis** Fitch, 1856l:523.
Blissus leucopterus nigricornis (Fitch).

210. **Micropus leucopterus rufipedis** Fitch, 1856l:523.
Blissus leucopterus rufipedis (Fitch).

Family PENTATOMIDAE

211. **Arma bracteata** Fitch, 1857m:336.
Apateticus bracteatus (Fitch).
Extant Specimens: Fitch's Type/Fitch's Collection/ 15,353 (USNM).

Order THYSANOPTERA

Family AEOLOTHRIPIDAE

212. **Coleothrips trifasciata** Fitch, 1855h:385.
Aeolothrips fasciatus (Linneaus).

Family THRIPIDAE

213. **Thrips tritici** Fitch, 1855h:385.
Frankliniella tritici (Fitch).

Family PHLAEOTHRIPIDAE

214. **Phlaeothrips caryae** Fitch, 1857m:445.
Liothrips caryae (Fitch).

215. **Phlaeothrips mali** Fitch, 1855n:806.
Haplothrips mali (Fitch).

Order NEUROPTERA

Family CONIOPTERYGIDAE

216. **Aleuronia westwoodii** Fitch, 1855n:802.
Malacomyza westwoodii (Fitch).
Original Specimens: 11,624, Salem, NY, 11.vii.1846, edge of Mrs.Fitch's woods, on hazel leaf; 11,874, Salem, NY, 29.vii.1846, beat from pine(?) bushes, on dugway hill; *4600, Salem, NY, 26.vi.1847, in front yard or in office; **4390, Salem, NY, 6.vii.1854, beat from apple trees, Jarvis Martin's orchard; Salem, NY, 5.vi.1855, flying, at sunset, at the meadow gate.

Family HEMEROBIIDAE

217. **Hemerobius alternatus** Fitch, 1855n:797.
Wesmaelius longifrons (Walker).
Original Specimens: *3107, Salem, NY, 26.vi.1846, beat from trees in Jarvis Martin's woods; *4661, Salem, NY, 28.vi.1847, on walnut, west border of Jarvis Martin's woods; *4682-86, Salem, NY, 28.vi.1847, on hemlock and pine bushes, west border of Jarvis Martin's woods.
Extant Specimens: *3107/Type 10451/*Hemerobius alternatus* (MCZ); *4682/Fitch Collection/*Hemerobius alternatus* (USNM); *4685, Fitch Collection/*H.altern.*var.a (USNM).

218. **Hemerobius amiculus** Fitch, 1855n:799.
Sympherobius amiculus (Fitch).
Original Specimens: *2131, Salem, NY, 20.viii.1852, on basswood bush, Esq.Martin's meadow; **3964, Salem, NY, 30.v.1854, about the house; 9085, IL, 7.x.1854, beat from peach trees, Burnett's.
Extant Specimens: **3964/Type 10449/*Hemerobius amiculus* (MCZ); 9085/Fitch Collection/*Hem.amic.*var.a (USNM).

219. **Hemerobius castaneae** Fitch, 1855n:798.
Hemerobius humulinus Linnaeus.
Original Specimens: *729-36, Salem, NY, 26.iv.1845, resting on pine leaves, Jarvis Martin's woods; *915, Salem, NY, 5.v.1845, on the wing by pine leaves, Jarvis Martin's woods; *3498, Stillwater, NY, 16.vii.1846, on chestnut bushes, west of grandmother's; *3991, Greenwich, NY, 24.viii.1846, on chestnut trees, near P.C.Dunlap's; *6095, Salem, NY, 19.viii.1847, on chestnut bushes, east side of Mrs.Fitch's woods; *7886, Salem, NY, 25.vii.1848, on willows, Esq.Martin's meadow; **2129-30, Salem, NY, 20.viii.1852, on basswood leaves, Esq.Martin's meadow; *2158, Salem, NY, 20.viii.1852, on pig walnut leaves, Esq.Martin's meadow; Salem, NY, 31.viii.1854, beat from chestnut leaves, north of Jarvis Martin's woods; 9607-08, IL, 20.ix.1854, beat from bushes, two miles south of the city of Chicago; 8362, Mercer Co., IL, 2.x.1854, on bushes along Henderson River; 8178, Mercer Co., IL, 2.x.1854, beat from apple trees, Burnett's.
Extant Specimens: Type 18453/*Hemerobius castaneae* (MCZ).
Note: Fitch's specimen 9608, in the MCZ collection, has been considered a type of *Hemerobius tutatrix* Fitch.

220. **Hemerobius conjunctus** Fitch, 1855n:798.
Hemerobius conjunctus Fitch.
Original Specimens: *2689, Salem, NY, 20.v.1846, beat from pine bushes, northwest corner of farm.
Extant Specimens: *2689/Type 10455/*Hemerobius conjunctus* (MCZ).

221. **Hemerobius delicatulus** Fitch, 1855n:800.
Psectra diptera (Burmeister).
Original Specimens: 8200, IL, 4.x.1854, swept from prairie grass, by Burnett's.
Extant Specimens: 8200/Type 10450/*Hemerobius delicatulus*, Illinois (MCZ).

222. **Hemerobius hyalinatus** Fitch, 1855n:799.
Hemerobius conjunctus pinidumus Fitch.
Original Specimens: *3796, Salem, NY, 29.vii.1846, on pine leaves, dugway woods; *8808, Salem, NY, 10.v.1851, on pine leaves, west border of Jarvis Martin's woods.
Extant Specimens: *3796, Fitch Collection, *Hem. hyalin.* var.a/*Hemerobius hyalinatus* Fitch (USNM); *8808/Type 10457/*Hemerobius hyalinatus* (MCZ).

223. **Hemerobius occidentalis** Fitch, 1855n:799.
Sympherobius occidentalis (Fitch).
Original Specimens: 8392, IL, 2.x.1854, on ash leaves, beside Henderson River.

224. **Hemerobius pinidumus** Fitch, 1855n:799.
Hemerobius conjunctus pinidumus Fitch.
Original Specimens: *3795, Salem, NY, 29.vii.1846, on pines, dugway woods; 12,337-338, Salem, NY, 1.vi.1847, on the wing among pine bushes in the pine woods; *7560, Salem, NY, 26.v.1848, on pines, northwest corner of my farm; 13,142, Salem, NY, 1850.
Extant Specimens: 12,338/Type 10456 (MCZ).

225. **Hemerobius stephensii** Fitch, 1855n:797.
Hemerobius stigma Stephens.
Note: Fitch proposed *Hemerobius stephensii* as a replacement name for *H. irroratus* Stephens, which is preoccupied by *irroratus* Say.

226. **Hemerobius stigmaterus** Fitch, 1855n:797.
Hemerobius stigmaterus Fitch.

Original Specimens: Greenwich, NY, 8.iv.1830, on pine tree in a swampy grove; 1545, Stillwater, NY, 4.v.1837, among pine bushes, by Wilbur's basin; 10,076, Jackson, NY, 30.iii.1845, on hemlock bushes, above red bridge, 10,110, Salem, NY, 12.iv.1845, on window of my room; *6523, Salem, NY, 11.ix.1847, on willows, Esq.Martin's meadow; **4362, Salem, NY, 4.vii.1854, swept from marshy grass in meadow; 9609-11, IL, 20.ix.1854, beat from bushes, two miles south of the city of Chicago; 8360-61, Mercer Co., IL, 2.x.1854, on bushes, north side of Henderson River; 8384-85, Mercer Co., IL, 2.x.1854, on walnut bushes, north side of Henderson River; 8390-91, Mercer Co., IL, 2.x.1854, on ash bushes, north side of Henderson River; 8415, Mercer Co., IL, 2.x.1854, on hazelnut bushes, north side of Henderson River; 8520-21, Mercer Co., IL, 2.x.1854, swept from grass on prairies; 9084, Mercer Co., IL, 7.x.1854, beat from peach leaves; 8179, Mercer Co., IL, 4.x.1854, beat from apple leaves, Burnett's.

Extant Specimens: 10,110/Type/*H.stig*.var.c (MCZ); *6523/Type/*H.stigma*.var.a (MCZ); *8384,/Type 10452/ *Hemerobius stigmaterus* (MCZ); 8391/Type/*H.stig*.var.b (MCZ).

227. **Hemerobius tutatrix** Fitch, 1855n:798.

Hemerobius humulinus Linnaeus.

Original Specimens: 12,059, Greenwich, NY, 26.ix.1846, on the wing about P.C.Dunlap's apple trees; 13,141, Salem, NY, 1850; Salem, NY, 3.ix.1855, in front yard, flying.

Extant Specimens: 9608/Collection Fitch, Fitch's Type (USNM); Type 10454/*H.tutatrix* (MCZ).

Note: According to Dr.Fitch's specimen registers and manuscript species notes, specimen 9608 is *Hemerobius castaneae* Fitch.

Family CHRYSOPIDAE

228. **Chrysopa albicornis** Fitch, 1855n:788.

Chrysopa oculata Say.

Original Specimens: 4116-17, Jackson, MS, iv.1852, from Sara E.Fitch.

Extant Specimens: Type 10481/*Chrysopa albicornis*, Mississippi, S.E.F./4116 (MCZ).

229. **Chrysopa bipunctata** Fitch, 1855n:791.

Chrysopa oculata Say.

Original Specimens: 12,335, Salem, NY, 3.vi.1847, on the wing, roadside above the dugway hill.

Extant Specimens: 12,335/*Chrysopa bipunctata*/Type 10482 (MCZ).

230. **Chrysopa chi** Fitch, 1855n:791.

Chrysopa chi Fitch.

Original Specimens: *9788, Hartford, NY, 27.vi.1851, on weeds in the big swamp.

Extant Specimens: *9788/*Chrysopa chi*/Type 10484 (MCZ).

231. **Chrysopa colon** Fitch, 1855n:792.

Chrysopa nigricornis (Burmeister).

Original Specimens: 10,445, Salem, NY, 5.vi.1845, weeds, east end of Battle Hill.

Extant Specimens: 10,445/*Chrysopa colon*/Type 10488 (MCZ).

232. **Chrysopa emuncta** Fitch, 1855n:792.

Meleoma emuncta (Fitch).

Original Specimens: *6010, Salem, NY, 19.viii.1847, beat from white oak, by Jas.Conner's.

Extant Specimens: *6010/*Chrysopa emuncta*/Type 10492 (MCZ).

233. **Chrysopa filicornis** Fitch, 1855n:795.

Original Specimens: Society Islands, Pacific Ocean, from Lieut.Pattison, U.S.Navy.

234. **Chrysopa fulvibucca** Fitch, 1855n:790.

Chrysopa oculata Say.

Original Specimens: Salem, NY, 10.viii.1854, in the office, in the evening.

235. **Chrysopa harrisii** Fitch, 1855n:794.

Chrysopa harrisii Fitch.

Original Specimens: 12,327-334, Stillwater, NY, 16.vii.1846, on the leaves of the pitch pine bushes west of the road past grandmother's and towards the sand hills.

Extant Specimens: 12,329/*Chrysopa harrisii*/Type 10494 (MCZ).

236. **Chrysopa illepida** Fitch, 1855n:788.

Chrysopa oculata Say.

Original Specimens: 7898, Ottawa, IL, 1854, from Dr.Harris; **5532, East Greenwich, NY, 26.vi.1855, in Wm.R.Watson's garden, at dusk.

Extant Specimens: **5532/*Chrysopa illepida*, female/ Type 10483 (MCZ).

237. **Chrysopa lineaticornis** Fitch, 1855n:795.

Chrysopa lineaticornis Fitch.

Original Specimens: *5132, Stillwater, NY, 15.vii.1847, on oak leaves.

Extant Specimens: *5132/*Chrysopa lineaticornis*/Type 10489 (MCZ).

238. **Chrysopa mississippiensis** Fitch, 1855n:790.

Chrysopa oculata Say.

Original Specimens: 4118, Jackson, MS, iv.1852, from Sara E.Fitch.

Extant Specimens: 4118/*Chrysopa mississippiensis*, Mississippi, S.E.F./Type 10486 (MCZ).

239. **Chrysopa novaeboracensis** Fitch, 1855n:794.

Chrysopa rufilabris Burmeister.

Original Specimens: Salem, NY, 19.vii.1854, flew in at open window, evening; Salem, NY, 25.vi.1855, flying among grass in front yard, at dusk; Salem, NY, 28.vi.1855, flying among grass in front yard; Salem, NY, 28.vi.1855, flying among grass near Jarvis Martin's.

Extant Specimens: *Chrysopa novaeboracensis*/Type 10490 (MCZ).

240. **Chrysopa omikron** Fitch, 1855n:789.

Chrysopa oculata Say.

Original Specimens: 10,093, Stillwater, NY, 14.vi.1837; 8381, Salem, NY, 17.vi.1844, attracted by lamp, in evening, dugway woods; **4962, Salem, NY, 8.ix.1854, attracted into house by candle, evening; **8497-99, Salem, NY, 18.vi.1855, flying about pines, dugway woods; **5529-31, East Greenwich, NY, 26.vi.1855, in Wm.B. Watson's garden at dusk; Salem, NY, 1.vii.1855, on grass in the back yard; Salem, NY, 20.viii.1855, in front yard; Salem, NY, 22.viii.1855, in front yard.

Extant Specimens: 8381/Collection Fitch (USNM); **4962/*Chrysopa omikron*/Type 10480 (MCZ); **5530/ Collection Fitch (USNM).

Note: A specimen in the USNM collection bears Fitch's label **8167. According to Fitch's specimen registers, this specimen was collected in 1858, and, therefore, it is not part of the original type series.

241. **Chrysopa plorabunda** Fitch, 1855n:792.
Chrysopa plorabunda Fitch.
Original Specimens: 13,963, Salem, NY, 20.x.1853, on garret window; 9615, IL, 20.ix.1854, on bushes, two miles south of the city of Chicago; 9409, Mercer Co., IL, 27.ix.1854; 8359, Mercer Co., IL, 2.x.1854, on bushes by Henderson River; 8383, Mercer Co., IL, 2.x.1854, on walnut bushes by Henderson River; 8457, Mercer Co., IL, 2.x.1854, on *Solidago* weeds by Henderson River; 8201, Mercer Co., IL, 4.x.1854, on grass along Duck Creek; 8158-72, Mercer Co., IL, 4.x.1854, beat from apple trees, Burnett's farm; 8592-94, Mercer Co., IL, 6.x.1854, swept from clover, Burnett's farm; 9151-52, Mercer, Co., IL, on weeds, timber along Henderson River; 9265, Mercer Co. IL, 6.x.1854, on oak bushes along Henderson River; 9080-83, Mercer Co., IL, 7.x.1854, beat from peach trees, Burnett's farm.
Extant Specimens: 8592/*Chrysopa plorabunda*/Type 10493 (MCZ); 8170/*Chr. plorab.*/Type 10496 (MCZ).
Note: Fitch's specimen 8170, in the MCZ collection, has been considered a type of *Chrysopa pseudographa*.

242. **Chrysopa pseudographa** Fitch, 1855n:793.
Chrysopa plorabunda Fitch.
Original Specimens: 8173-77, Mercer Co., IL, 4.x.1854, beat from apple trees, A.Burnett's; 9150, Mercer Co., IL, 6.x.1854, beat from weeds, in woods along Henderson River; 9083, Mercer Co., IL, 7.x.1854, beat from peach trees, A.Burnett's.
Note: A specimen in the MCZ collection bears Fitch's label 8170, and it is considered the type of *Chrysopa pseudographa*. According to Fitch's manuscript notes, he considered specimen 8170 to be *Chrosopa plorabunda*, so this specimen cannot be considered the type.

243. **Chrysopa puncticornis** Fitch, 1855n:796.
Chrysopa lineaticornis Fitch.
Original Specimens: *5131, Stillwater, NY, 15.vii.1847, on oak leaves.

244. **Chrysopa robertsonii** Fitch, 1855n:792.
Chrysopa plorabunda Fitch.
Original Specimens: Tullehassie, AR, 13.v.1855, from Wm.S.Robertson.
Extant Specimens: *Chrysopa robertsonii*, Arkansas/Type 10495 (MCZ).

245. **Chrysopa sichelii** Fitch, 1855n:793.
Chrysopa quadripunctata Burmeister.
Original Specimens: Salem, NY, 1.viii.1855, on leaves of elm tree in front yard; Salem, NY, 14.viii.1855, flying in front yard, about an *Aphis*-infested Balm of Gilead, at midnight.
Extant Specimens: *Chrysopa sichelii*/Type 10491 (MCZ).

246. **Meleoma signoretii** Fitch, 1855n:786.
Meleoma signoretii Fitch.
Original Specimens: 521, Rupert, VT, 20.vii.1848, on Mt.Antonio, near its summit.
Extant Specimens: 521/Fitch Collection/*Meleoma signoretii* Fitch, Vermont/det.C.Tauber '68 (USNM).

247. **Chrysopa sulphurea** Fitch, 1855n:793.
Chrysopa quadripunctata Burmeister.
Original Specimens: 1940, New Brunswick, NJ, 23.ix.1851, beat from walnut bushes.

248. **Chrysopa tabida** Fitch, 1855n:796.
Chrysopa interrupta Schneider.
Original Specimens: Salem, NY, 2.viii.1855, on locust leaves in front yard.

249. **Chrysopa upsilon** Fitch, 1855n:791.
Chrysopa chi Fitch.
Original Specimens: 10,409, Salem, NY, 4.vi.1845, in Chester Martin's meadow.
Extant Specimens: 10,409/*Chrysopa upsilon*/Type 10485 (MCZ).

250. **Chrysopa virginica** Fitch, 1855n:795.
Allochrysa virginica (Fitch).
Original Specimens: 698-99, Cartersville, VA, winter 1847-1848, from Thaddeus A.Culbertson.

251. **Chrysopa xanthocephala** Fitch, 1855n:789.
Chrysopa oculata Say.
Original Specimens: 10,384, Salem, NY, 2.vi.1845, in meadow above White Creek; 12,510, Salem, NY, 21.vi.1847, in the front yard; 12,747, Canajoharie, NY, from Wm.S. Robertson; 9967, North Cannon, Kent Co., MI, from T.E. Wetmore.
Extant Specimens: *C.xanthocephala*/Type 10487 (MCZ).

Order COLEOPTERA

Family CICINDELIDAE

252. **Cicindela johnsonii** Fitch, 1857m:487.
Cicindela circumpicta Laferte.

Family BUPRESTIDAE

253. **Chalcophora novaeboracensis** Fitch, 1858e:701.
Chalcophora virginiensis Drury.
Original Specimens: 5033, Terrytown, PA, vii(?).1852, from George T.Horton; **2926, Salem, NY, vi.1853, in front yard; Salem, NY, 16.ix.1857, in pine woods, taken by T.R.Ashton; 14,855, Salem, NY, 8.vii.1858, on young pines.

254. **Chalcophora oregonensis** Fitch, 1858e:702.
Chalcophora oregonensis Fitch.

255. **Chalcophora virginiensis immaculata** Fitch, 1858e:700.

Family COCCINELLIDAE

256. **Adonia parenthesis albomaculata** Fitch, 1861hh:853.
Hippodamia parenthesis (Say).

257. **Adonia parenthesis approximata** Fitch, 1861hh:853.
Hippodamia parenthesis (Say).

258. **Coccinella novemnotata confluenta** Fitch, 1861hh:849.
Coccinella novemnotata Herbst.
Original Specimens: 5443, Stillwater, NY, 1835.

259. **Adonia parenthesis confluenta** Fitch, 1861hh:853.
Hippodamia parenthesis (Say).

260. **Coccinella novemnotata conjuncta** Fitch, 1861hh:849.
Coccinella novemnotata Herbst.
Original Specimens: 9931, North Cannon, Kent Co., MI, from T.E.Wetmore.

261. **Adonia parenthesis connata** Fitch, 1861hh:854.
Hippodamia parenthesis (Say).

262. **Adonia parenthesis discopunctata** Fitch, 1861hh:853.
Hippodamia parenthesis (Say).
Original Specimens: *9530, Salem, NY, 9.vi.1851, west border of Jarvis Martin's woods, on grass in a marshy spot.

263. **Coccinella novemnotata divisicollis** Fitch, 1861hh:849.
Coccinella novemnotata Herbst.
Original Specimens: 13,943, Salem, NY, 2.xi.1853, Titus's hill.

264. **Coccinella novemnotata inaequalis** Fitch, 1861hh:849.
Coccinella novemnotata Herbst.

265. **Adonia parenthesis insulata** Fitch, 1861hh:854.
Hippodamia parenthesis (Say).

266. **Coccinella quinquenotata interrupta** Fitch, 1861hh:851.
Coccinella transversoguttata Falderman.

267. **Adonia parenthesis linearis** Fitch, 1861hh:853.
Hippodamia parenthesis (Say).
Original Specimens: 13,786, Canajoharie, NY, from Wm.S.Robertson.

268. **Adonia parenthesis lituricollis** Fitch, 1861hh:853.
Hippodomia parenthesis (Say).

269. **Adonia parenthesis nimia** Fitch, 1861hh:854.
Hippodamia parenthesis (Say).

270. **Coccinella novemnotata parvamaculata** Fitch, 1861hh:849.
Coccinella novemnotata Herbst.
Original Specimens: 2484, Tullehassie, AR, from Wm. S. Robertson.

271. **Adonia parenthesis permacrifrons** Fitch, 1861hh:853.
Hippodamia parenthesis (Say).

272. **Adonia parenthesis triangularis** Fitch, 1861hh:853.
Hippodamia parenthesis (Say).

273. **Adonia parenthesis tridentifrons** Fitch, 1861hh:853.
Hippodamia parenthesis (Say).

Family MELOIDAE

274. **Canatharis pyrivora** Fitch, 1857m:354.
Lytta sayi (LeConte).
Original Specimens: 2960-61, Canajoharie, NY, vi.1838, from Wm.S.Robertson; *1704-05, Newburgh, NY, vi.1838, from Drs.Prime and Emmons.

Family SCARABAEIDAE

275. **Macrodactylus barbatus** Fitch, 1863e:681.
Macrodactylus subspinosus (Fabricius).
Original Specimens: 327,427, Salem, NY, 1831; **7220, Greenbush, NY, 22.vii.1857, on roses; *8768-69, Saratoga Springs, NY, 26.vi.1863, on grape vines, from Mr.Chase; 7516, Canajoharie(?), NY, from Wm.S.Robertson; 14,391, Brooklyn, NY, from Stephen Calverly.

276. **Anomola lucicola maculicollis** Fitch, 1857m:403.
Original Specimens: 5532, Stillwater, NY, 1.vii.1836, on elm; east side of Bartlett's swamp; *3464-71, Stillwater, NY, 16.vii.1846, on wild grapevines, west of grandmother's; *3476, Stillwater, NY, 16.vii.1846, on pines, west of grandmother's; *5145, Stillwater, NY, 15.vii.1847, on walnut bushes, west of grandmother's; *7715, Salem, NY, 6.vii.1848, on grapevines, in the meadow.

277. **Valgus serricollis** Fitch, 1858e:697.
Valgus canaliculatus Oliver, NEW SYNONYMY.
Original Specimens: 3539-40, Jackson, MS, 2.iv.1852, from Sara E.Fitch.

Family CERAMBYCIDAE

278. **Saperda lateralis abbreviata** Fitch, 1859d:841.
Saperda lateralis Fabricius.
Original Specimens: *1193, Greenwich, NY, 13.vi.1845, on raspberry briars, north of Peter Dunlap's.

279. **Phymatodes albofasciatus** Fitch, 1859d:793.
Original Specimens: **1258-60, Salem, NY, 28.v.1852, on trunk of a black oak tree, Jarvis Martin's woods.

280. **Saperda tridentata intermedia** Fitch, 1858d:840.
Saperda tridentata Olivier.
Original Specimens: Salem, NY, 4.vii.1858, "...a specimen showed me, captured by Baron Osten Sacken, on the window of the hotel."

281. **Eupogonius pinivora** Fitch, 1858e:712.
Eupogonius tomentosus (Haldeman).
Original Specimens: 14,861-862, Salem, NY, 8.vii.1858, beat from young pines, pine woods.

282. **Leiopus querci** Fitch, 1859d:796.
Urgleptes querci (Fitch).
Original Specimens: *4895, Salem, NY, 5.vii.1847, on black oak, bank of the kill; *6775, Long Island, NY, 1847, from Wm.S.Robertson.

283. **Saperda tridentata rubronotata** Fitch, 1859d:840.
Saperda tridentata Olivier.
Original Specimens: 14,924, New York, NY, from T.B.Ashton.

284. **Saperda lateralis suturalis** Fitch, 1859d:841.
Saperda lateralis Fabricuis.
Original Specimens: *4658, Salem, NY, 28.vi.1847, on walnut, Jarvis Martin's woods.

Family CHRYSOMELIDAE

285. **Crioceris trilineata tripunctata** Fitch, 1865l:446.
Lema trilineata (Olivier).

286. **Crioceris trilineata unipunctata** Fitch, 1865l:446.
Lema trilineata (Olivier).

Family BRUCHIDAE

287. **Bruchus fabae** Fitch, 1861g:63.
Acanthoscelides obtectus (Say), NEW SYNONYMY.

Family SCOLYTIDAE

288. **Hylastes carbonarius** Fitch, 1858e:730.
Hylastes porculus Erichson.
Original Specimens: *3561, Salem, NY, 15.vii.1846, about the house and yards.
Extant Specimens: *3561/Collection Fitch/Type No. 42808, U.S.N.M./*Hylastes carbonarius* (USNM).

289. **Tomicus xylographus fulvus** Fitch, 1858e:716.

290. **Tomicus mali** Fitch, 1857m:326.
Monarthrum mali (Fitch).
Original Specimens: *1862-66, Middlefield, MA, 6.vi.1857, from Lawrence Smith; 3273, OH, from Dr.Robert H.Mack.

291. **Tomicus materiarius** Fitch, 1858e:726.
Gnathotrichus materiarius (Fitch).
Original Specimens: 26.i.1858, from burrow in dead pine.

292. **Tomicus xylographus niger** Fitch, 1858e:716.

293. **Tomicus xylographus nigricollis** Fitch, 1858e:716.

294. **Hylastes pinifex** Fitch, 1858e:729.
Hylurgops pinifex (Fitch).
Original Specimens: 1527-28, Stillwater, NY, 4.v.1837, near Wilbur's Basin; *7268, Salem, NY, iv.1848, yard of Jarvis Martin's sawmill; **758-67, Salem, NY, 7.v.1852, on new pine boards.

Order MECOPTERA

Family BOREIDAE

295. **Boreus brumalis** Fitch, 1847g:278.
Boreus brumalis Fitch.
Original Specimens: *1864, Salem, NY, i.1846, woodlot by McDougall's Lake; 12,250, Salem, NY, 9.ii.1847, on snow, big hill; 12,256, Salem, NY, 9.ii.1847, on snow, woods south of McDougall's; 4267-70, 4.iii.1847, on melting snow, woodlot by McDougall's Lake.
Note: A specimen in the USNM collection bears Fitch's label 14,520. Two specimens in the MCZ collection bear his labels **316 and *7095, and they are also labeled "Type." According to Fitch's specimen registers, these specimens were collected in 1856, 1851, and 1848, respectively. Therefore, they are not part of the original type series.

296. **Boreus nivoriundus** Fitch, 1847g:277.
Boreus nivoriundus Fitch.
Original Specimens: 9974-75, Salem, NY, 15.iii.1845, walking on snow that had fallen the night before, east border of beech woods, south of McDonald's; 10,031-053, Salem, NY, 5.iv.1845, east border of beech woods, south of McDonald's; 10,061-066, Salem, NY, 7.iv.1845, on snow, in Jarvis Martin's woods; *1860-61, Salem, NY, i.1846, woodlot by McDougall's Lake; *4248-49, Salem, NY, 2.ii.1847, on melting snow, woodlot by McDougall's Lake; 12,251-255, Salem, NY, 9.ii.1847, woods of big hill and woods south of McDougall's; *4264-66, Salem, NY, 4.iii.1847, on melting snow, woodlot by McDougall's Lake.
Note: Two specimens in the USNM collection bear Fitch's labels 14,528 and 15,001. Two specimens in the MCZ collection bear his labels *8088 and *8090, and they are also labelled "Type." According to Fitch's specimen registers these specimens were collected in 1856, 1859, 1851, and 1851, respectively. Therefore, they are not part of the original type series.

Order DIPTERA

Family TRICHOCERIDAE

297. **Trichocera brumalis** Fitch, 1847g:283.
Trichocera brumalis Fitch.
Original Specimens: 12,112-123, Salem, NY, 28.xii.1846, on snow on the big hill.

Family CULICIDAE

298. **Culex hyemalis** Fitch, 1847g:281.
Anopheles punctipennis (Say).
Original Specimens: Salem, NY, 14.xi.1845, on window; Greenwich, NY, 17.xi.1845, on window at Peter Dunlap's; Salem, NY, 8.xii.1845, on window of back room.
Extant Specimens: 6850/Type No., U.S.N.M./Fitch's Collection/*Anopheles* Meigen, *hyemalis*, Fitch, New York (USNM); Type of A.Fitch/Type 4049/*Anopheles* (*Culex*) *hyemalis*, Fitch (MCZ).

Family CHIRONOMIDAE

299. **Chironomus nivoriundus** Fitch, 1847g:282.
Diamesa nivoriunda (Fitch).
Original Specimens: 10,055, Salem, NY, 5.iv.1845, in Teff's woods, with *Boreus nivoriundus*; 10,056, Salem, NY, 7.iv.1845, in Jarvis Martin's woods, with *Boreus nivoriundus*; *4252, Salem, NY, 2.ii.1847, on snow, woodlot by McDougall's Lake; *4090-92, Salem, NY, 4.iii.1847, on snow, wood lot by McDougall's Lake; 12,290-317, Salem, NY, spring 1847, on melting snow.

Family SCIARIDAE

300. **Molobrus fuliginosus** Fitch, 1856l:487.
Sciara fuliginosa (Fitch).
Original Specimens: *1287, 24.vi.1845, Salem, NY, near outlet of McDougall's Lake; 10,653, Salem, NY, 27.vi.1845, on weeds and grasses, near the outlet of McDougall's Lake; 10,689, *1351, Greenwich, NY, 1.vii.1845, woods west of Alex.Cherry's; 11,114, Salem, NY, 11.viii.1845, on office window.

301. **Molobrus inconstans** Fitch, 1856l:487.
Sciara inconstans (Fitch).
Original Specimens: 14,143, Salem, NY, 21.xii.1855, evening, on paper on writing table; Salem, NY, 24.xii.1855, on office window, two specimens seen.

302. **Molobrus mali** Fitch, 1856l:484.
Lycoriella mali (Fitch).
Extant Specimens: *Molobrus mali* Fitch, *Lycoriella*, ex Fitch Coll.(USNM).

303. **Molobrus vulgaris** Fitch, 1856l:487.
Sciara vulgaris (Fitch).
Original Specimens: 10,627, 10,639, Salem, NY, 27.vi.1845, on office window; *1350, Greenwich, NY, 1.vii.1845, woods west of Alex.Cherry's; 10,688, Salem, NY, 3.vii.1845, on office window; 10,726, 10,729-730, 10,736, Salem, NY, 8.vii.1845, on grass in front yard; 10,947, Salem, NY, 21.vii.1845, on office window; 10,957, Salem, NY, 21.vii.1845, swamp on Deacon Clark's woodlot; 11,057-060, Salem, NY, 1.viii.1845, on office window; 11,073, 11,106-107, Salem, NY, 7.viii.1845, on office window; 11,197-198, Salem, NY, 12.viii.1845, on window in back room, in home.

Family CECIDOMYIIDAE

304. **Cecidomyia amyotii** Fitch, 1861hh:773.
Sitodiplosis mosellana (Géhin).
Original Specimens: Salem, NY, 12.vi.1861, around lamp in house.

305. **Cecidomyia caliptera** Fitch, 1845c:262.
Lestodiplosis caliptera (Fitch).
Original Specimens: 10,846, Salem, NY, 11.vii.1845, on office window; 11,032, Salem, NY, 1.viii.1845, on office window; 11,084, 11,087, Salem, NY, 7.viii.1845, on office window; 11,115, Salem, NY, 11.viii.1845, on office window; 11,337-338, 11,347, 11,351, 11,365, Salem, NY, 16.viii.1845, on office window; 11,416, Salem, NY, ix.1845, on office window.
Extant Specimens: 10,846, from Fitch Collection, *Cecidomyia caliptera* Fh.,mntd.1969 R.J.G., Can.balsam (USNM).

306. **Cecidomyia cerealis** Fitch, 1845c:263.
Clinodiplosis graminia (Fitch).
Note: *Cecidomyia ceralis* Fitch is a junior secondary homonym of *C.cerealis* (Sauter), 1817. Fitch proposed *C.graminis* as a replacement name.

307. **Cecidomyia graminis** Fitch, 1861hh:832.
Clinodiplosis graminis (Fitch).
Original Specimens: 10,519, Salem, NY, 16.vi.1845, Jarvis Martin's wheat field; 10,721, Salem, NY, 8.vii.1845, among grass in front yard; 11,164, 11,166, Salem, NY, 12.viii.1845, on back room window; 11,339, 11,344, 11,349, 11,350, Salem, NY, 16.viii.1845, on office window; 11,417, Salem, NY, ix.1845, on office window.
Note: Fitch proposed *Cecidomyia graminis* as a replacement name for *C.cerealis* Fitch, which is preoccupied by *C.cerealis* (Sauter).
Three specimens in the USNM collection bear Fitch's labels 11,571, 16,848, and 17,000. According to Fitch's specimen registers, the first specimen was collected in 1846, and the latter two in 1872. Therefore, they are not part of the original type series.

308. **Cecidomyia grossulariae** Fitch, 1855n:880.
Clinodiplosis grossulariae (Fitch), NEW COMBINATION.
Original Specimens: NY, July, in some gooseberries prematurely turned red, and with their pulp putrid.
Extant Specimens: USNM (Slide), from Fitch Collection, mtd.1969 R.J.G., Can.balsam (USNM, two specimens).

309. **Cecidomyia inimica** Fitch, 1861hh:830.
Mycodiplosis inimica (Fitch).

310. **Cecidomyia pseudacaciae** Fitch, 1859d:833.
Dasineura pseudacaciae (Fitch).
Original Specimens: Vial No.114, July to August, 1854, larvae in the leaves of the locust tree.

311. **Cecidomyia salicis** Fitch, 1845b:263.
Mayetiola rigidae (Osten Sacken).
Original Specimens: NY, forming galls the size of a sparrow's egg on the tips of willow twigs, in winter and again in summer.
Extant Specimens: *Cecidomyia salicis* Fitch, Salem, NY, from willow galls, April 1, '52 (MCZH); Loew Coll./ *Cecidomyia salicis* Fitch, female (MCZ).

312. **Cecidomyia tergata** Fitch, 1845c:264.
Original Specimens: 11,044-045, Salem, NY, 1.viii.1845, on office window; 11,081, Salem, NY, 7.viii.1845, on office window; 11,136-149, Salem, NY, 12.viii.1845, on window of back room, in house.

313. **Cecidomyia thoracica** Fitch, 1845c:264.
Mycodiplosis thoracica (Fitch), NEW COMBINATION.
Original Specimens: 11,372, 11,375, 11,383, 11,387, 11,407, Salem, NY, 16 & 18.viii.1845, on office window.

Family ASILIDAE

314. *Trupanea apivora* Fitch, 1864f:63.
Promachus fitchii Osten Sacken.
Note: *Trupanea apivora* Fitch is a junior primary homonym of *T. apivora* Walker, 1860.

Family EMPIDIDAE

315. **Oscinis crassifemoris** Fitch, 1856l:533.
Platypalpus crassifemoris (Fitch).
Original Specimens: Salem, NY, 30.vi.1856, swept from wheat.
Extant Specimens: *Oscinis crassifemoris*/Type No.789, U.S.N.M./*Platypalpus crassifemoris* (Fitch) Coq.(USNM).

Family DIOPSIDAE

316. **Sphyracephala subbifasciata** Fitch, 1855n:774.
Sphyracephala brevicornis (Say).
Original Specimens: 7906, north of Ottawa, IL, 17.x.1854, swept from grass, at base of the bluffs, in company with Dr.J.C.Harris; **5912-22, Salem, NY, 8.x.1855, in sand gully, east end of Battle Hill; **6021-26, Salem, NY, 10.x.1855, in sand gully, east end of Battle Hill.

Extant Specimens: **5912/30/Loew/Type A.Fitch/ *subbifasciata* (MCZ); **6022/Loew/Type of A.Fitch/ *Sphyracephala subbifasciata* Fitch (MCZ); **6024/Loew/Type A.Fitch (MCZ); Fitch Coll./*Sphyracephala subbifasciata* (USNM).

Family PLATYSTOMATIDAE

317. **Tephritis melliginis** Fitch, 1855n:769.
Rivellia melliginis (Fitch).
Original Specimens: NY, 3.vii.1855, on Balm of Gilead twigs infested by aphids.
Extant Specimens: Fitch Coll./*Tephritis melliginis* Fitch (USNM).

Family TEPHRITIDAE

318. **Acinia novaeboracensis** Fitch, 1855n:771.
Eutreta sparsa (Wiedemann).
Original Specimens: *5445, Salem, NY, 27.vii.1847, on *Cornus paniculata*, Esq.Martin's meadow by kill; **5768-69, Salem, NY, 20.vii.1855, beat from weeds on Small's I., Batten Kill.
Extant Specimens: **5768/Type No.4394, U.S.N.M./ *Acinia novaeboracensis* (USNM).

319. **Acinia solidaginis** Fitch, 1855n:771.
Eurosta solidaginis (Fitch).
Original Specimens: 10,139-144, NY, hatched about 1.iv.1845 from galls placed in stove room, 19.ii; **5393, 24.v.1855, hatched from *Solidago* gall, in the office.
Extant Specimens: *Acinia solidaginis* Fitch/Type No.788 (USNM).

320. **Tephritis tabellaria** Fitch, 1855n:770.
Rhagoletis tabellaria (Fitch).
Original Specimens: **5750, Salem, NY, 20.vii.1855, on weeds on Small's Island, Batten Kill.

Family SCIOMYZIDAE

321. **Tetanocera saratogensis** Fitch, 1855n:772.
Limnia sp.
Original Specimens: **1441, Salem, NY, 8.vii.1845, on grass in front yard.
Extant Specimens: Fitch Coll./*Tetanocera saratogensis*/ *Limnia saratogensis* Fitch (USNM).

Family LAUXANIIDAE

322. **Chlorops antennalis** Fitch, 1856l:532.
Camptoprosopella antennalis (Fitch).
Original Specimens: Salem, NY, 28 & 30.vi.1856, swept from wheat.

323. **Chlorops vulgaris** Fitch, 1856l:532.
Camptoprosopella vulgaris (Fitch).
Original Specimens: 30.vi.1856, swept from young wheat.
Extant Specimens: *Chlorops vulgaris* (USNM).
Note: The label on the above specimen is written in Fitch's handwriting, but it is not labelled as a type.

Family MILICHIIDAE

324. **Agromyza tritici** Fitch, 1856l:534.
Meoneura obscurella (Fallén).
Original Specimens: 14,266-291, Salem, NY, from Harvey's wheat, in barn, threshed.
Extant Specimens: 14,269/Fitch's Type/From Fitch's Collection/*Agromyza tritici*/Type No.787, U.S.N.M./Type of *Agromyza tritici* Fitch (USNM).

Family CHLOROPIDAE

325. **Meromyza americana** Fitch, 1856l:531.
Meromyza americana Fitch.
Original Specimens: Salem, NY, 28.vi.1856, swept from spring wheat.
Extant Specimens: *Meromyza americana*/Fitch's Type, from Fitch's Collection/Type No.786 (USNM).

326. **Oscinis coxendix** Fitch, 1856l:533.
Apallates coxendix (Fitch).
Original Specimens: Salem, NY, 30.vi.1856, swept from growing wheat.
Extant Specimens: *Oscinis coxendix*/Fitch's Type/From Fitch's Collection/Type No.385 (USNM).

327. **Chlorops hortensis** Fitch, 1872a:363.
Thaumatomyia glabra (Meigen).

328. **Siphonella obesa** Fitch, 1856l:531.
Thaumatomyia glabra (Meigen).
Extant Specimens: *Siphonella obesa*/Fitch's Type/From Fitch's Collection (USNM).

329. **Oscinis tibialis** Fitch, 1856l:532.
Rhopalopterum soror (Macquart).
Original Specimens: Salem, NY, 30.vi.1856, swept from growing wheat.
Extant Specimens: *Oscinis tibialis*/Type No.384 (USNM).

Family ANTHOMYIIDAE

330. **Hylemyia deceptiva** Fitch, 1856l:533.
Delia platura (Meigen).
Original Specimens: *4438-45, *4447-49, Salem, NY, 25.vi.1847, in Josephus Martin's winter wheat; *4736-41, Salem, NY, 30.vi.1847, in Josephus Martin's winter wheat.

331. **Hymelyia similis** Fitch, 1856l:533.
Delia platura (Meigin).
Original Specimens: *4434, *4436-37, *4440, Salem, NY, 25.vi.1847, on wheat heads in Josephus Martin's field; *4742-46, Salem, NY, 30.vi.1847, on wheat heads in Josephus Martin's field.

Family CUTEREBRIDAE

332. **Cuterebra emasculator** Fitch, 1857m:478.
Cuterebra emasculator Fitch.
Original Specimens: 2831, Tullehassie, AR, 1851, from Wm.S.Robertson; 13.viii.1856, in scrotum of striped squirrel, from Peter Reid.

Extant Specimens: Fitch's Type/From Fitch's Collection/ TD 4652/*Cuterebra emasculator*, Fh./positively *not* the holotype!! Disagrees with descr'n, important characters!!, Det.CHTT/probably *augustifrons* Dalmat, det.Sabrosky (USNM).

Order LEPIDOPTERA

Family PIERIDAE

333. **Nathalis irene** Fitch, 1857m:485.
Nathalis iole Boisduval.
Original Specimens: 2717, Tullehassie, AR, 1851, from Wm.S.Robertson.

334. **Colias santes** Fitch, 1854c:378.
Colias philodici Godart.
Original Specimens: *6680, Salem, NY, autumn 1847.

Family NYMPHALIDAE

335. **Vanessa lintnerii** Fitch, 1857m:485.
Nymphalis antiopa lintnerii (Fitch).

Family NOLIDAE

336. **Brachytaenia triquetrana** Fitch, 1856l:476.
Celama triquetrana (Fitch).
Original Specimens: *749, Salem, NY, 26.iv.1845, flying, around Jarvis Martin's woods.

Family ARCTIIDAE

337. **Hyphantria collaris** Fitch, 1857m:383.
Cycnia tenera Hübner.
Original Specimens: 7241, Jackson, MS, 1853, from Sara E.Fitch.

338. **Hyphantria punctata** Fitch, 1857m:383.
Hyphantria cunea Drury.
Original Specimens: *7652, Salem, NY, 22.vi.1848, laying its eggs on ash, front yard; 1138, Tullehassie, AR, vi.1851, from Wm.S.Robertson; *4274, Salem, NY, 28.vi.1854, swept from grass in the meadow; Salem, NY, 15.vi.1856, in the woods on Battle Hill; 14,635, Salem, NY, 14.vi.1857, on a dead twig, dugway woods.

339. **Atolmis tricolor** Fitch, 1857m:486.
Hypoprepia fucosa Hübner.
Original Specimens: 6814, Salem, NY, 1831; *3265, Salem, NY, 10.vii.1846, beat from pine bushes on the dugway; *3341, Salem, NY, 13.vii.1846, beat from bushes, in meadow, by footbridge; 11,821-822, Salem, NY, 24.vii.1846, at rest upon the leaves of a beech tree, border of Jarvis Martin's woods; 5090, Terrytown, PA, vii.1852, from Geo.F.Horton; **4566, Salem, NY, 20.vii.1854, in the yard; Salem, NY, 3.viii.1855, in the house, evening; **7140, Salem, NY, 20.vii.1857, resting, in candlelight on front stoop; 12,901, Canajoharie, NY, from Wm.S.Robertson; Schoharie, NY, taken by J.A.Lintner.

Family NOCTUIDAE

340. **Hadena amputatrix** Fitch, 1857m:425.
Septis arctica Boisduval.
Original Specimens: Salem, NY, 1829; Salem, NY, 1831; *1418, Salem, NY, 5.vii.1845, on office window, evening; *1854, Salem, NY, viii.1845, about the house; *3552, Salem, NY, vi.1846, about the house; 89, East Greenwich, RI, viii.1846, from Pliny F. Martin; **1785, Salem, NY, 7.vii.1852, behind window shutters of office; **2913, Salem, NY, 28.vi.1853, evening, in the house; **3084, Salem, NY, 8.vii.1853, in front yard at twilight; **4204-05, Salem, NY, 26.vi.1854, in the house; 12,910, Canajoharie(?), NY, from Wm.S.Robertson.

341. **Hypena elegantalis** Fitch, 1856l:559.
Pangrapta decoralis Hübner.

342. **Agrotis nigricans maizi** Fitch, 1865g:804.
Euxoa tessellata maizi (Fitch).

343. **Brachytaenia malana** Fitch, 1856l:473.
Balsa malana (Fitch).
Original Specimens: *4944, Salem, NY, 6.vii.1847, in front yard; 14,139, Salem, NY, 25.vii.1854, hatched from worm fed on apple; 14,140, Salem, NY, 19.xii.1855, hatched from worm fed on apple; 14,150, Salem, NY, 23.i.1856, hatched from worm fed on spple.
Extant Specimens: 14,140, (*Brachytaenia*) Steph., *malana*, Fitch, New York/Type No.225 (USNM).

344. **Alaria volupia** Fitch, 1868b:908.
Rhododipsa volupia (Fitch).
Original Specimens: *1040, Tullehassie, AR, 1855, from Wm.S.Robertson.
Extant Specimens: *Alaria volupia*, Fh./*1040/Type No.283 (USNM).

Family NOTODONTIDAE

345. **Clostera albosigma** Fitch, 1856l:506.
Melalopha albosigma (Fitch).
Original Specimens: Salem, NY, 25.vii.1855, hatched in the office; Salem, NY, 13.vii.1856, in house, morning, on walls, Agricultural Museum.
Extant Specimens: *Clostera* Hoffman, *albosigma*, Fitch, White S, New York/Type No.356 (USNM).

346. **Clostera vau** Fitch, 1859d:845.
Melalopha apicalis Walker.
Original Specimens: 6812, Stillwater(?), NY; 15,020, Salem, NY, 4.vi.1859, on kitchen window, in the morning.

Family LYMANTRIIDAE

347. **Orgyia leucostigma borealis** Fitch, 1856d:218.
Orgyia leucostigma intermedia Fitch.
Extant Specimens: *Org.leucostig.borealis*/Type No.1412, U.S.N.M./Slide No.52015, D.C.Ferguson (USNM).

348. **Orgyia leucostigma intermedia** Fitch, 1856l:445.
Orgyia leucostigma intermedia Fitch.
Original Specimens: 14,156, Salem, NY, 31.vii.1855.
Extant Specimens: 14,156/Type No.1413, U.S.N.M./*O. leucostigma*., B.*intermedia*, New York (USNM).

349. **Orgyia nova** Fitch, 1863e:675.
Orgyia antiqua nova Fitch.
Original Specimens: 15,391-392, Salem, NY, 10.vii.1863, resting on its cocoon, newly hatched; 15,393, 20.vii.1863, in office, flitting about for the female; 15,394, 20.vii.1863, female, newly hatched from cocoon; 15,399, 27.vii.1863, male, that paired with the preceeding.
Extant Specimens: 1539/*Orgyia nova*/Type No. 354, U.S.N.M./male gen.slide, by DCF, USNM 52342/Figured in Moths of America North of Mexico (USNM).

Family LASIOCAMPIDAE

350. **Planosa laricis** Fitch, 1856l:494.
Tolype laricis (Fitch).
Original Specimens: *5923, vicinity of Albany, NY, 1847, taken by Mr.Salisbury; Salem, NY, 24.vii.1854, hatched from cocoons.
Extant Specimens: *P.laricis*, female/New York/Type No.357 (USNM).
Note: A specimen in the USNM collection bears Fitch's label 16,004, and it is also labelled "Type." According to Dr. Fitch's specimen registers, this specimen was collected in 1871, and, therefore, it is not part of the original type series.

Family GEOMETRIDAE

351. **Priocycla johnsonaria** Fitch, 1871:530.
Euchlaena johnsonaria (Fitch).
Original Specimens: Salem, NY, 28.vi.1870, flew in at open door of office, attracted by lamp.
Extant Specimens: *Priocycla johnsonaria*, Fitch/Type No.4317 (USNM).

352. **Abraxas(?) ribearia** Fitch, 1848b:466.
Itame ribearia (Fitch).
Original Specimens: 8614, Salem, NY, 1.vii.1844, in front yard, caught by lamp light; 8729-34, Salem, NY, 2.vii.1844, evening, taken by lamp light; *316, Salem, NY, 13.vii.1844, attracted into window, by candlelight; *3535-50, Salem, NY, 17.vi.1846, in Emmons' garden, about currant bushes; *3555, Salem, NY, 17.vi.1846; *3238-39, Salem, NY, 9.vii.1846, about the house and office; *4782, Salem, NY, 30.vi.1847, about the house; *4942, Salem, NY, 6.vii.1847, in front yard; *5012, Salem, NY, 10.vii.1847, attracted into house, by candlelight; *5088, Saratoga Springs, NY, 16.vii.1847; *5019-21, Salem, NY, 17.vii.1847, attracted into house by candlelight.

353. **Geometra(?) siccifolia** Fitch, 1857m:381.
Nemoria bistriata bistriata Hübner, NEW SYNONYMY.

354. **Amilapis triplipunctata** Fitch, 1859d:825.
Hypagyrtis unipunctata (Haworth).
Original Specimens: Salem, NY, 3.vii.1859, hatched from larva beat from white oaks on Battle Hill, 11.vi.1859.
Extant Specimens: July 9, '59, Battle Hill (USNM).

Family PYRALIDAE

355. **Tinea zeae** Fitch, 1856l:552.
Plodia interpunctella Hübner.
Original Specimens: *4183, East Greenwich, NY, 17.xi.1846, in cracks in the walls of the gristmill; Salem, NY, 8.ix.1855, in a bag of emptying cakes, abundant with its larvae feeding upon them; 14,155, Salem, NY, 26.ii.1856, flying in office, near bag of cakes; Salem, NY, 20.vi.1856, flying in office near bag of cakes.

Family PTEROPHORIDAE

356. **Pterophorus cineridactylus** Fitch, 1855n:848.
Oidaematophorus monodactylus (Linnaeus).
Original Specimens: **5649, Salem, NY, 10.vii.1855, in front yard, taken by candlelight.

357. **Pterophorus cretidactylus** Fitch, 1855n:849.
Oidaematophorus cretidactylus (Fitch).
Original Specimens: 13,843, Stillwater, NY, 12.vii.1836, in woods west of grandmother's.

358. **Pterophorus lobidactylus** Fitch, 1855n:847.
Trichoptilus lobidactylus (Fitch).
Original Specimens: *7667, Salem, NY, 28.vi.1848, border of Esq.Martin's meadow, on bushes.

359. **Pterophorus marginidactylus** Fitch, 1855n:848.
Platyptilia pallidactyla (Haworth).
Original Specimens: 8426, Salem, NY, 21.vi.1844, on plants in the meadow.

360. **Pterophorus naevosidactylus** Fitch, 1855n:849.
Oidaematophorus monodactylus (Linnaeus)
Original Specimens: **3339, Salem, NY, 11.viii.1853, in the house, evening; Salem, NY, 10.viii.1854, in the house, evening; **4792, Salem, NY, 23.viii.1854, evening, in house.

361. **Pterophorus nebulaedactylus** Fitch, 1855n:849.
Platyptilia pallidactyla (Haworth).
Original Specimens: 8378, Salem, NY, 17.vi.1844, evening, dugway woods, taken by lamp; 8624, Salem, NY, 1.vii.1844, evening, in front yard, taken by lamp; *3005-06, Salem, NY, 18.vi.1846, evening, in front yard; *4789, Salem, NY, 5.vii.1847, about the house; *4966, Salem, NY, 9.vii.1847, in the house, attracted by lamp; *4989, Salem, NY, vii.1847, in the house; **5648, Salem, NY, 10.vii.1855, in front yard, attracted by lamp.

362. **Pterophorus periscelidactylus** Fitch, 1855n:843.
Pterophorus periscelidactylus Fitch.
Original Specimens: Union Village, NY, 16.vi.1855, caterpillars upon the Isabella grapevines in Mr.Master's garden, on the younger and more tender leaves.

363. **Pterophorus tenuidactylus** Fitch, 1855n:848.
Pterophorus tenuidactylus Fitch.
Original Specimens: *1497, Salem, NY, 14.vii.1845, north base of Battle Hill; 10,891, Granville, NY, 16.vii.1845, sphagnous swamp, on the wing; *3422, Stillwater, NY, 16.vii.1846, on white pine, in big swamp.

Family OLETHREUTIDAE

364. **Ephippophora caryana** Fitch, 1857m:459.
Cydia caryana (Fitch).
Original Specimens: 14,571-572, Easton, NY, iv.1857, from Lewis Potter.

Extant Specimens: 14,571/*Ephippophora*? *caryana*/Type No.394 (USNM).

Note: A specimen in the USNM collection bears Fitch's label 14,957, and it is also labelled "Type." According to Fitch's specimen registers, this specimen was collected in 1859, and, therefore, it is not part of the original type series.

Family TORTRICIDAE

365. **Lozotaenia cerasivorana** Fitch, 1857m:382.
Archips cerasivorana (Fitch).
Original Specimens: *157, Salem, NY, 9.vii.1844, in front yard, by candlelight; **7128, Salem, NY, 18.vii.1857, on front porch, by candlelight; **7081, Salem, NY, 19.vii.1857, on chokecherry, meadow over White Creek; Salem, NY, 21.vii.1857, on chokecherry.

366. **Croesia persicana** Fitch, 1857m:357.
Archips persicana (Fitch).
Original Specimens: Salem, NY, 6.vii.1857, bred from larva on peach leaves, specimen in Agricultural Museum.

367. **Argyrolepia quercifoliana** Fitch, 1859d:826.
Argyrotaenia quercifoliana (Fitch).
Original Specimens: **4464-65, Salem, NY, 9.vii.1854, in woods on Battle Hill.

Family COCHYLIDAE

368. **Argyrolepia pomariana** Fitch, 1853a (unpaged).

369. **Argyralepia sylvaticana** Fitch, 1853a (unpaged).
Original Specimens: *354, Salem, NY, 17.vii.1844, in woods of woodlot, by McDougall's Lake; *3531, Stillwater, NY, 16.vii.1846, in house, attracted by candle; *6123, Salem, NY, 21.viii.1847, near McDougall's Lake, in the woods.

Family COSSIDAE

370. **Cossus querciperda** Fitch, 1859d:790.
Prionoxystus macmurtrei Guérin-Méneville.
Extant Specimens: *Cossus querciperda*, 270, Type, Fitch, male (NYSM); *Cossus querciperda*, 137, Type, Fitch, female (NYSM).

Family GELECHIIDAE

371. **Chaetochilus contubernalellus** Fitch, 1853b:39.
Dichomeris ligulella Hübner.
Original Specimens: **3076, Salem, NY, 8.vii.1853, in front yard at twilight; **3205, Salem, NY, 9.vii.1853, on weeds, under a white oak, northeast corner of upper island, in the meadow.

372. **Chaetolochilus malifoliellus** Fitch, 1856l:463.
Dichomeris ligulella Hübner.

373. **Anacampsis robiniella** Fitch, 1859d:834.
Recurvaria robiniella (Fitch).
Original Specimens: **4252-54, Salem, NY, 27.vi.1854, evening, attracted into house, by light; **5585, Salem, NY, 5.vii.1855, evening, in the office; 15,045, Salem, NY, 4.viii.1859, evening, around lamp in house.

374. **Chaetochilus ventrellus** Fitch, 1856l:466.
Dichomeris ventrella (Fitch).
Original Specimens: **5947, Salem, NY, 1.xi.1855, flying, in dugway woods.
Extant Specimens: **5947/Stephens, *Chaetochilus ventrellus* Fitch MSS, New York/This specimen is from Fitch's own collection and is presumably his true type/ Genitalia slide by JFGC, male, USNM 10,641 (USNM).

Family OECOPHORIDAE

375. **Chaetochilus trimaculellus** Fitch, 1856l:465.
Eido trimaculella (Fitch).
Original Specimens: Salem, NY, 21.vi.1856, resting on door-post of office, in shade.
Extant Specimens: This spcm found in Fitch's Coll. with his label undoubtedly is the true type!, AB 1900 (USNM).

Family PLUTELLIDAE

376. **Cerostoma brassicella** Fitch, 1855n:874.
Plutella maculipennis Curtis.
Original Specimens: *283, Salem, NY, 13.vii.1844, singed by lamp, in house, evening; **4741, Salem, NY, 15.viii.1854, in garden upon beet leaves; 7883-90, near Ottawa, IL, 15.x.1854, abundant in gardens.

Family YPONOMEUTIDAE

377. **Deiopeia aurea** Fitch, 1857m:486.
Attava aurea (Fitch), NEW COMBINATION.
Original Specimens: *1355, Savannah, GA, 1856, from Mrs.Wm.G.Dickson.

Family GRACILARIIDAE

378. **Argyromiges morrisella** Fitch, 1859d:838.
Phyllonorycter morrisella (Fitch).
Original Specimens: 19.i.1859, torpid, under shaggy bark of hickory.
Extant Specimens: Type/Figured by Miss A. Braun, Febr.1908/*Argyromiges morrisella*, Fh.(USNM).

379. **Argyromiges ostensackenella** Fitch, 1859d:838.
Phyllonorycter ostensackenella (Fitch).
Original Specimens: Right hand specimen, Salem, NY, 1.vii.1856, on office window in the morning; Left hand specimen, Salem, NY, 16.viii.1857, evening, in the house, on table, by candle.
Extant Specimens: *Argyromiges ostensackenella*, Fh./ Type No.512 (USNM, two specimens mounted together).

380. **Argyromiges pseudacaciella** Fitch, 1859d:836.
Phyllonorycter robiniella Clemens.
Original Specimens: *8155-57, Salem, NY, 12.iii.1851, torpid, under crevices of shaggy bark of hickory, pasture north of creek.
Extant Specimens: *Argyromiges pseudacaciella*/Type No. 514 (USNM).

381. **Argyromiges quercialbella** Fitch, 1859d:828.
Phyllonorycter quercialbella (Fitch).

Original Specimens: 13,848-849, 1846, bred from pupae in leaves gathered this year; Salem, NY, 23.v.1857, flying, on Battle Hill, among oaks, at sunset.

Extant Specimens: *Argyromiges quercialbella*, Fh./Type No.513 (USNM).

382. **Argyromiges quercifoliella** Fitch, 1859d:827.
Phyllonorycter fitchella Clemens.
Original Specimens: 16,985, Salem, NY, 4.xi.1857, larva mining chestnut oak leaves in front yard, put in a vial and this hatches therefrom.

383. **Argyromiges uhlerella** Fitch, 1859d:838.
Phyllonorycter uhlerella (Fitch).
Original Specimens: *8158, Salem, NY, 12.iii.1851, under bark of shaggy walnut, north of the creek, torpid.
Note: An insect pin in the USNM collection bears Fitch's label *8158, but the specimen is missing and, presumably, destroyed.

Family INCURVARIIDAE

384. **Ornix acerifoliella** Fitch, 1856l:501.
Paraclemensia acerifoliella (Fitch).
Original Specimens: *2690, Salem, NY, 20.v.1846, beat from pines, northwest corner of mill lot; *7339, Salem, NY, 12.v.1848, on maple leaves in meadow; **1168, Salem, NY, 24.v.1852, hatched from cases; **2817-18, Salem, NY, 21.v.1853, in woods on Battle Hill; **4531, Salem, NY, 11.vii.1854, hatched in the office.
Extant Specimens: *Ornix acerifoliella* Fitch/Fitch's type, Ang.Busck (USNM).

Order HYMENOPTERA

Family CIMBICIDAE

385. **Abia cerasi** Fitch, 1857m:385.
Trichiosoma triangulum Kirby.
Original Specimens: Salem, NY, 28.iii.1857, cocoon adhering to a twig of cherry, two feet above the ground, south side of Battle Hill; Salem, NY, 22.iv.1857, near the same spot, found another cocoon picked open by birds, on the upper side of a horizontal twig, three feet above the ground.

Family DIPRIONIDAE

386. **Lophyrus lecontei** Fitch, 1858e:744.
Neodiprion lecontei (Fitch).
Original Specimens: 7847, east of New Brunswick, NJ, 15.v.1854, swept from grass, border of woods.
Extant Specimens: Fitch Coll./7847/134, wing mounted/ *Lophyrus lecontei* Fitch, female, Type?(USNM).

Family TENTHREDINIDAE

387. **Selandria(?) juglandis** Fitch, 1857m:467.
Eriocampa juglandis (Fitch).
Original Specimens: Salem, NY, 6.vii.1855, on the underside of a leaflet on the butternut at corner of the woodshed, save a dead one in balsam, on mica.

388. **Nematus suratus** Fitch, 1857m:386.
Nematus ventralis Say.
Original Specimens: 14,577, Salem, NY, 28.iv.1857, hatch in office.
Extant Specimens: Fitch's Type/Fitch's Coll./*Nematus suratus* Fitch/Type No.1797 (USNM).

Family CEPHIDAE

389. **Janus flaviventris** Fitch, 1862k:851.
Janus integer (Norton).
Original Specimens: 1831, Stillwater, NY, last of May, 1837.
Extant Specimens: 1831/*Janus flaviventris*/*Janus integer* Nort., Det.D.T.Ries, 1935 (USNM).

Family BRACONIDAE

390. **Sigalphus curculionis** Fitch, 1859c:221.
Nealiolis curculionis (Fitch).
Original Specimens: *2619-22, St.Catherines, Canada West, 15.vii-12.viii.1859, hatched from *Curculio* larvae in black knots, D.W.Beadle.
Extant Specimens: Fitch's Type/From Fitch's Collection/ *2622/Type No.3756 (USNM).

391. **Aphidius lactucaphis** Fitch, 1855n:840.
Blacus exilis (Nees).
Original Specimens: 27.viii.1855, found dead, adhering to a leaf of lettuce, surrounded by *Aphis* sp.
Extant Specimens: Fitch's Type/Type No.1821/From Fitch's Collection/*Aphidius lactucaphis* (USNM).

392. **Microgaster robiniae** Fitch, 1859d:836.
Apanteles robiniae (Fitch).
Original Specimens: 6.iv.1859, in the white blisters of locust leaves (five of these hatched in vial, and dead, I gum to card, with two cocoons).
Extant Specimens: Fitch's Type/From Fitch's Collection/ Type No.1814/*Microgaster robiniae*/*Apanteles robiniae* Fitch, female (USNM, two glue spots, fragments of three adults, and two cocoons, on a card).

393. **Toxares triticaphis** Fitch, 1861hh:840.
Pentapleura triticaphis (Fitch).
Original Specimens: 15,183, Salem, NY, 15.v.1861, in young winter wheat, of Arnott's.
Extant Specimens: 15,183/Fitch's Type/Type No.1817 (USNM).

Family APHIDIIDAE

394. **Praon avenaphis** Fitch, 1861hh:840.
Aphidius avenaphis (Fitch).
Original Specimens: 3.vii.1861, on winter wheat, with *Aphis avenae*, two specimens; 15,224, 9.vii.1861, hatched from *Aphis avenae*.

395. **Trioxys cerasaphis** Fitch, 1855n:842.
Praon cerasaphis (Fitch).
Extant Specimens: Fitch's Type/From Fitch's Collection/ Type No.1818/*Praon cerasaphis*/*Trioxys cerasaphis* (USNM).

396. **Praon avenaphis obscura** Fitch, 1861hh:841.

Original Specimens: 15,226, 13.vii.1861, hatched from *Aphis avenae*; 15,240, 5.xi.1861, swept from rye with *Aphis avenae*.

Extant Specimens: 15,240/Fitch's Type/From Fitch's Collection/*Praon avenaphis*/*Aphidius avenaphis* Fitch, male/ Type No.1815 (USNM); a.*obscura*/Fitch's Type/From Fitch's Collection/*Praon avenaphis*/*Aphidius avenaphis* Fitch, male/ Type No.1815 (USNM).

397. **Praon polygonaphis** Fitch, 1855n:840.

Aphidius polygonaphis (Fitch).

Original Specimens: 26.viii.1855, hatched from *Aphis* on *Polygonum*.

Extant Specimens: Fitch's Type/Type No.1816, U.S. N.M./From Fitch's Collection/(*Aphidius*) *Praon* Nees., *polygonaphis*, Fitch, New York (USNM).

398. **Trioxys populaphis** Fitch, 1855n:841.

Lysiphlebus salicaphis (Fitch).

Original Specimens: 19.viii.1855, hatched from an *Aphis* on Balm of Gilead poplar; 14,113, x.1855, hatched from an *Aphis* on Balm of Gilead poplar.

Extant Specimens: 14,113/Fitch's Type/From Fitch's Collection/Type No.1819/*Trioxys populaphis* (USNM).

399. **Trioxys salicaphis** Fitch, 1855n:841.

Lysiphlebus salicaphis (Fitch).

Original Specimens: Salem, NY, 13.vii.1855, three specimens hatched from willow lice gathered in the meadow day before yesterday; 14.vii.1855, ten more specimens, from same.

Extant Specimens: Fitch's Type/Type No.1830, U.S. N.M./From Fitch's Collection/*Trioxys salicaphis* (USNM).

400. **Praon viburnaphis** Fitch, 1855n:841.

Lysiphlebus viburnaphis (Fitch).

Original Specimens: 16.viii.1855, hatched from an *Aphis* sp.

Extant Specimens: Fitch's Type/14,734/From Fitch's Collection/Type No.1356/(*Aphidius*) *Praon* Nees, *viburnaphis*, Fitch, New York (USNM).

Note: Fitch's specimen registers indicate that specimen 14,734 was probably collected in 1858, and, therefore, it probably is not part of the original type series.

Family ICHNEUMONIDAE

401. **Ichneumon leucaniae** Fitch, 1861f:276.

Pterocormus laetus (Brulle).

Original Specimens: 15,232, 20.viii.1861, hatched from pupae of army worm; 15,233, 26.viii.1861, hatched from pupae of army worm.

402. **Phygadeuon planosae** Fitch, 1856l:501.

Chromocryptus planosae (Fitch).

Original Specimens: vii.1854, hatched from *Planosa laricis*, 5 females.

Extant Specimens: Type No.1813/New York (USNM).

403. **Cenocoelius(?) ribis** Fitch, 1857m:422.

Original Specimens: 6.vi.1857, from currant stalks.

Family EULOPHIDAE

404. **Trichogramma(?) fraterna** Fitch, 1856d:235.

Horismenus fraternus (Fitch).

Original Specimens: **5837, Salem, NY, 16.ix.1855, on rose leaves under front room window.

Extant Specimens: **5837/Fitch's Type/From Fitch's Collection/Type No.1837/*Trichogramma*(?) Westwood, *fraterna*, Fitch, New York (USNM).

405. **Trichogramma(?) orgyiae** Fitch, 1856d:235.

Eulophus orgyiae (Fitch).

Original Specimens: 11,902-923, 7.viii.1846, hatched from a caterpillar of *Orgyia leucostigma*.

Extant Specimens: 11,914/Fitch's Type/From Fitch's Collection/Type No.1838/*Trichogramma*(?) Westwood, *orgyiae* Fitch, New York (USNM).

Family ENCYRTIDAE

406. **Platygaster lecanii** Fitch, 1859d:805.

Coccophagus lycimnia (Walker).

Original Specimens: **3785, **4122, 5.vi.1854, from pupae of *Lecanium quercitronis*.

Extant Specimens: **3785/Fitch's Type/Type No.1828/ From Fitch's Collection/*Platygaster*? *lecanii*, Fitch (USNM).

Family TORYMIDAE

407. **Torymus harrisii** Fitch, 1862k:839.

Cryptopristus harrisii (Fitch).

Original Specimens: *2616-17, 3750-92, 3.v.1852, hatched from diseased Virginia wheat straw from Dr.T.W. Harris.

Family PTEROMALIDAE

408. **Cleonymus clisiocampae** Fitch, 1856l:432.

Dibrachys cavus (Walker).

Original Specimens: 8.viii.1856, from pupae in caterpillar nests on chokecherry.

Extant Specimens: Fitch's Type/From Fitch's Collection/ Type No.1831 (USNM).

409. **Pteromalus onerati** Fitch, 1859d:812.

Habrocytus onerati (Fitch).

Original Specimens: 10,180-182, Salem, NY, 12.v.1845, taken from a jar of squamous-imbricated willow galls which were gathered March 6th; 27.iv.1857, two specimens dead and worthless, in a vial of bullet-like oak galls put up March 28th.

Extant Specimens: 10,180/Fitch's Type/Type No.1834/ *Pteromalus onerati* (USNM).

410. **Pteromalus quercipilulae** Fitch, 1859d:819.

Ormyrus quercipilulae (Fitch).

Original Specimens: 15.iv.1859, from pea-like galls on oak leaves.

Extant Specimens: Fitch's Type/From Fitch's Collection/ Type No.1835/*Pteromalus quercipilulae* Fh.(USNM).

411. **Pteromalus tabacum** Fitch, 1865g:792.

Hypopteromalus tabacum (Fitch).

Original Specimens: 15,428, 6.ix.1862, fourteen specimens from cocoons on larva of *Sphinx*; 15,424, 28.viii.1864, wandering between the cocoons of *Microgaster* sp., on the back of a *Sphinx* – perhaps to oviposit in the cocoons; 15,425, 12.xii.1864, hatched from the same cocoons, in vial, in the office, 15,426, 12.xii.1864, thirteen specimens, I gum the most perfect ones to a slip of card, all females; 15,427, 15.xii.1864, from the same cocoons; 15,433, 16.xii.1864, hatched from the same cocoons as above; 28.xii.1864, two more flies come from same cocoons.

Extant Specimens: 15,424/15,425/15,427/15,433/Fitch's Type/From Fitch's Collection/*Pteromalus tabacum*/Type No. 1836 (USNM, five specimens mounted together, one without individual, numbered label).

Family EURYTOMIDAE

412. **Spalangia quercilanae dorsalis** Fitch, 1859d:816.
Eudecatoma quercilanae (Fitch).
Original Specimens: 4.v.1857, seven specimens hatched from wooly galls on white oak leaves.
Extant Specimens: 14,574/Fitch's Type/Type No.1833/ From Fitch's Collection/*S.quercilanae* a.*dorsalis* (USNM).

413. **Eurytoma flavipes** Fitch, 1862k:845.
Harmolita hordei (Harris).
Note: This is an incorrect subsequent spelling of *fulvipes* Fitch, 1859.

414. **Pteromalus(?) fulvipes** Fitch, 1859i:115.
Harmolita hordei (Harris).
Original Specimens: **4119-21, Salem, NY, 10.vi.1854, swept from wheat stalks, Josephus Martin's hill; Cazenovia, NY, 24.vii.1857, in a vial of dry barley straw, from L.Lincklaen.

415. **Eurytoma lanulae** Fitch, 1859d:817.
Eurytoma studiosa Say.
Original Specimens: *1072-78, 10.v.1845, dead, in jar of conglomerate galls of willow gathered February 22nd; 14,573, 28.iv.1857, from a gall put up three weeks ago; 4.v.1857, one specimen from same gall.
Extant Specimens: From Fitch's Collection/6628/Type No.1824 (USNM, two specimens mounted together).

416. **Macroglenes querciglobuli** Fitch, 1859d:812.
Eurytoma querciglobuli (Fitch).
Original Specimens: **6460-61, 12.vii.1856, dead in a tumbler of galls.
Extant Specimens: *6461/Fitch's Type/From Fitch's Collection/Type No.1829/*Macroglenes querciglobuli*, Fitch (USNM).

417. **Spalangia quercilanae** Fitch, 1859d:816.
Eudecatoma quercilanae (Fitch).
Original Specimens: 14,574-576, 28.iv.1857, six specimens, hatched from wooly galls on white oak leaves, taken three weeks ago; 4.v.1857, nine specimens more from same gall.
Extant Specimens: Fitch's Type/Type No.1832/From Fitch's Collection/*Spalangia*? *quercilanae* Fitch (USNM).

418. **Macroglenes quercipisi** Fitch, 1859d:819.
Original Specimens: 27.iv.1857, bred from galls placed in a vial April 2nd; 15.iv.1859, bred from whortleberry galls.
Note: A specimen in the USNM collection bears Fitch's label 15,213, and it is also labelled "Fitch's Type." According to Fitch's specimen registers this specimen was collected in 1861, and, therefore, it is not part of the original type series.

419. **Eurytoma secalis** Fitch, 1861bb:236.
Harmolita secalis (Fitch).
Original Specimens: *2627-29, PA, 3.vi.1861, eight specimens (two in Agricultural Museum) coming from rye straw, from American Agriculturist; Male, dead, in a vial of straw, ticketed "Joint worm in rye" - source forgotten, seven specimens.
Extant Specimens: *2628/Fitch's Type/Type No.1825/ From Fitch's Collection (USNM).

420. **Pteromalus(?) tritici** Fitch, 1859i:115.
Harmolita tritici (Fitch).
Original Specimens: 3746-91, VA, 6.v.1852, hatched from wheat straw, received April 1st, from Dr.T.W. Harris.
Extant Specimens: Fitch's Type/Type No. 1826 U.S.N.M./ From Fitch's Collection/Md.E.L.Rogers (USNM).

Family EUCOILIDAE

421. **Allotria avenae** Fitch, 1861hh:842.
Kleidotoma avenae (Fitch).
Original Specimens: 15,185, 17.v.1861, swept from rye, with *Aphis avenae*.
Extant Specimens: 15,185/*Allotria avenae*/Fitch's Type/ Type No.1811 (USNM).

Family CHARIPIDAE

422. **Allotria tritici** Fitch, 1861hh:841.
Alloxysta tritici (Fitch).
Original Specimens: 8.vii.1861, swept from winter wheat, *Aphis* infested.

Family CYNIPIDAE

423. **Figites chinquapin** Fitch, 1859d:820.
Andricus chinquapin (Fitch).
Original Specimens: 11,620, the imago, and 11,621-622, its galls, Greenwich, NY, 5.v.1846, in the woods north of Peter Dunlap's?
Note: A specimen in the USNM collection bears the label "Type No.1800, *Andricus chinquapin* Fitch." Fitch did not consider it a specimen of this species, as his handwritten label bearing a different manuscript name indicates.

424. **Philonix fulvicollis** Fitch, 1859d:783.
Philonix fulvicollis Fitch.
Original Specimens: 14,508, Salem, NY, 12.xii.1856, on snow, Jarvis Martin's woods; 14,936-939, 23.xi.1858, on snow, Jarvis Martin's woods.
Extant Specimens: 14,508/Fitch's Type/Fitch's Collection/ *Philonix fulvicollis*, Fh./Type No.1802 (USNM).

425. **Biarhiza nigra** Fitch, 1859d:782.
Xystoteras nigrum (Fitch).

Original Specimens: **372, Salem, NY, 28.xi.1851, on snow, woodlot by McDougall's Lake, placed in Agricultural Museum.

426. **Philonix nigricollis** Fitch, 1859d:783.
Philonix nigricollis Fitch.
Original Specimens: 14,935, Salem, NY, 23.xi.1858, on snow, Jarvis Martin's woods.
Extant Specimens: 14,935/Fitch's Type/Fitch's Coll./ *Philonix nigricollis*, Fh./Type No.1803 (USNM).

427. **Cynips quercusarbos** Fitch, 1859d:809.
Ceroptres quercusarbos (Fitch).
Original Specimens: Salem, NY, 28.iii.1857, irregular knobs from tips of twigs of white oak in brother Harvey's field, south of Battle Hill, placed in vial, small *Cynips* found dead, May 27th.

428. **Cynips quercusbatatus** Fitch, 1859d:810.
Neuroterus quercusbatatus (Fitch).
Original Specimens: Gall found on a young shoot of white oak, March 1, 1858; in a vial in office twelve specimens, all females, hatched March 17, and two others gnawed a perforation almost large enough to escape.

429. **Cynips quercusficus** Fitch, 1859d:812.
Ceroptres quercusficus (Fitch).
Original Specimens: Salem, NY, April, young white oak limbs in abundance, grown over with these galls.
Extant Specimens: Fitch's Type/Fitch's Coll./Type No.1808/*Cynips quercusficus* (USNM, four specimens mounted together, but only one with above labels).

430. **Callaspidia quercusglobulus** Fitch, 1859d:810.
Disholcaspis quercusglobulus (Fitch).
Original Specimens: 1530, Stillwater, NY, 4.v.1837, Wilbur's Basin, on pine leaves; 11,465-466, Salem, NY, ix.1845; two specimens found dead in a tumbler in which bullet-like galls of white oak were placed.
Extant Specimens: Fitch's Type/Fitch's Coll./Type No. 1805/*Callaspidia quercusglobulus* Fh.(USNM, two specimens mounted together).

431. **Cynips quercuslana** Fitch, 1859d:814.
Synergus quercuslana (Fitch).
Extant Specimens: Fitch's Type/Fitch's Coll./*Cynips quercuslana*, Fh./Type No.1810 (USNM).

432. **Cynips quercuspisum** Fitch, 1859d:818.
Ceroptres quercuspisum (Fitch).
Original Specimens: i.1855, galls adhering to under surface of oak leaves; Salem, NY, 22.ix.1856, Battle Hill, another gall found and enclosed in a vial, hatched 1.iii.1857; 20.v.1857, five of these galls (one of them double) put in a vial April 3, the double gall hatches two specimens.

433. **Cynips quercustuber** Fitch, 1859d:806.
Ceroptres quercustuber (Fitch).
Original Specimens: Salem, NY, 19.iv.1859, find several of these galls on Titus's Hill.
Extant Specimens: Fitch's Type/Fitch's Coll./Type No.1809/*Cynips quercustuber* (USNM, three specimens mounted together).

434. **Figites rubuscaulis** Fitch, 1862c:335.
Original Specimens: Lockport, NY, 20.iii.1857, sixteen specimens from E.S.Holmes; 4.iv.1857, twelve specimens from a gall put in a jar a month ago; Poughkeepsie, NY, 5.iv.1862, twenty specimens from two galls, in a warm room since December 4, from Edward Merritt; 24.iv.1862, ten more from same galls.

Family DIAPRIIDAE

435. **Diapria agromyzae** Fitch, 1856l:535.
Trichopria agromyzae (Fitch).
Original Specimens: 14,235-237, Salem, NY, from wheat worms on threshing floor.
Extant Specimens: 14,235/Fitch Type/From Fitch's Collection/Type No.1841/*Diapria agromyzae* (USNM, two specimens mounted together).

Family SCELIONIDAE

436. **Telenomus orgyiae** Fitch, 1863e:679.
Telenomus dalmani Ratzeburg.
Original Specimens: 20.vi.1863, inserting its eggs into those of *Orgyia*.
Extant Specimens: Fitch's Type/From Fitch's Collection/ *Telenomus orgyiae*/Type No.1839 (USNM).

Family PLATYGASTERIDAE

437. **Platygaster error** Fitch, 1861hh:818.
Euxestonotus error (Fitch).
Original Specimens: 21.vi.1861, with midge, on winter wheat.

438. **Platygaster herrickii** Fitch, 1863j:312.
Platygaster hiemalis Forbes.

Family FORMICIDAE

439. **Formica caryae** Fitch, 1855n:855.
Camponotus caryae (Fitch).
Original Specimens: *8135-39, Salem, NY, 4.ii.1851, under shaggy bark of hickory trees, in orchard; **5039-65, Salem, NY, 29.i.1855, in burrows in bitter walnut firewood; **5249-77, Salem, NY, 2.iv.1855, in burrows in bitter walnut firewood.
Extant Specimens: *8135, **5058, **5064, **5251, **5253, **5262-64, **5267, **5271-73, **5275, **5277/ Fitch's Type/Type No.1842/Fitch's Collection (USNM, fourteen separate specimens); **5266/Fitch's Type/Type No.1842/ Fitch's Collection/*Formica caryae*, Fh., female (USNM); *8137, **5041-43, **5045, **5054-55 (MNHN, seven separate specimens).

440. **Myrmica cerasi** Fitch, 1855n:834.
Crematogaster cerasi (Fitch).
Extant Specimens: N.Y./Collection T. Pergande/No. 53583, Cotype (USNM).

441. **Formica novaeboracensis** Fitch, 1855n:766.
Camponotus novaeboracensis (Fitch).
Original Specimens: 9.iv.1855, in a burrow in decaying buttonwood; 12.viii.1855, guarding plant lice on apple

trees; 31.viii.1855, guarding plant lice on plum trees; 31.viii.1855, guarding plant lice on Balm of Gilead.

Extant Specimens: Fitch's Type/Type No. 1843, U.S.N.M./*Formica novaeboracensis* (USNM); Fitch's Type/Type No.1843, U.S.N.M./Fitch's Collection (USNM, two separate specimens).

Class ARACHNIDA

Order ARANEIDA

Family THERIDIIDAE

442. **Theridion brassicae** Fitch, 1871:563.

Theridion frondeum Hentz.

Original Specimens: 13.ix.1870, one or two seen on underside of three or four of the outer leaves of a young cabbage; 15.ix.1870, a larger one found on underside of a cabbage leaf, and smaller ones under three or four cabbage leaves.

Family EPEIRIDAE

443. **Epeira decipiens** Fitch, 1856l:451.

Araneus curcurbitinus Clerck.

Original Specimens: 14,162, Salem, NY, 20.iii.1856, in a tuft of dead leaves.

Family DICTYNIDAE

444. **Theridion hypophyllum** Fitch, 1871:564.

Dictyna foliacea (Hentz).

Original Specimens: 13,897, Salem, NY, 25.x.1853, on snow, Jarvis Martin's woods; 13,902, Salem, NY, 26.x.1853, in the office; 13,988, Salem, NY, 12.xi.1853, on wood pile, in the back yard; Salem, NY, 9.ix.1870, under cabbage leaves in the garden; Salem, NY, 1.x.1870, on underside of maple leaf in front yard; Salem, NY, 22.iv.1871, in garden.

Unplaced Araneida

445. **Ixodes(?) odontalgiae** Fitch, 1872a:371.

Extant Specimens: *Ixodes? odontalgiae*/Fitch's Collection/TYPE/Type No.1346 (U.S.N.M., National Parasite Collection No.3477).

Note: The specimen is an immature spider of unknown taxonomic affinity.

Order ACARINA

Family IXODIDAE

446. **Ixodes cruciarius** Fitch, 1872a:366.

Ixodes cookei Packard.

Original Specimens: 8.ix.1857, on Anna's arm; 15,669, 1.xi.1868, on a mink; 15,670, 1868, on Miss Turner's leg, in bed, by night.

Extant Specimens: 744/TYPE/Fitch's Collection/Fitch's Type/Type No.1347 U.S.N.M.(USNM, National Parasite, Collection No. 3476, National Tick Collection No. RML 118015).

447. **Ixodes quinquestriatus** Fitch, 1872a:366.

Dermacentor variabilis (Say).

Original Specimens: 744, Cartersville, VA, 1847, from Thaddeus A.Culbertson; 1256, Tullehassie, AR, 1850, from Wm.S.Robertson; 2995, Tullehassie, AR, from Wm.S. Robertson; 5688, 5760, Tullehassie, AR, vii.1852, from Wm. S.Robertson.

Extant Specimens: 2995/1256/5688/*Ixodes 5-striatus*, Ark., W.S.Rob./Fitch's Collection (USNM, 3 specimens in same vial, National Parasite Collection No. 3472, National Tick Collection No. RML 118013); 744/TYPE/Fitch's Collection/Fitch's Type/Type No.1348 U.S.N.M./*Ixodes 5-striatus*, Va., T.A.Culb.(USNM, National Parasite Collection No.3473, National Tick Collection No. RML 118014).

448. **Ixodes robertsonii** Fitch, 1872a:366.

Dermacentor variabilis (Say).

Original Specimens: 2859, Tullehassie, AR, 1851, from Wm.S.Robertson; 6364, IL, 13.viii.1852, from Wm.S. Robertson, bank of Illinois creek, Park hill.

Extant Specimens: 6364/*1639/TYPE/Type No.1351, USNM/*Ixodes robertsonii*, Fitch/Fitch's Collection (USNM, 2 specimens in same vial, National Parasite Collection No.3475, National Tick Collection No. RML 118012).

Family UROPODIDAE

449. **Uropoda formicae** Fitch, 1855n:857.

Family ACARIDAE

450. **Tyroglyphus ribis** Fitch, 1857m:424.

Family ORIBATULIDAE

451. **Oribata quadripilis** Fitch, 1857m:442.

REFERENCE NOTES

[1] A. Mallis, *American Entomologists* (New Brunswick, Rutgers University Press, 1971), p.42.

[2] A. Fitch (ed.), Say's heteropterous Hemiptera, *Trans. N.Y. State Agric. Soc.* 17 (1858):754-814.

[3] *International Code of Zoological Nomenclature*, Article 45(e)(i) (hereafter cited as *ICZN*).

[4] A. Fitch to T. W. Harris, letter dated 11 Aug.1852, file bMu 998.10.2, Museum of Comparative Zoology, Harvard University.

[5] F. G. Werner (ed.), *Common Names of Insects and Related Organisms* (Entomological Society of America, 1982), 132 pp.

[6] A. Fitch, "Facilities for making a collection," undated manuscript notes, New York State Museum.

[7] A. Fitch, "List of insects numbered with red ink. These are all North American, but collected out of the State of New York, but in other United States or Canada or north of there," 1830-1872, New York State Museum; F. G. Sanborn and J. A. Lintner, An account of the collections which illustrate the labors of Dr. Asa Fitch, *Psyche* 2 (1879):273-276 (hereafter cited as Sanborn and Lintner, Account).

[8] Anon., Dr. Fitch, *J. N.Y. State Agric. Soc.* 6 (June 1855):11.

[9] Asa Fitch Diary, 23 Aug.1870, Manuscript Group 215 (Asa Fitch Papers), Sterling Memorial Library (Manuscripts and Archives), Yale University (hereafter cited as Diary).

[10] C. V. Riley, Dr. Asa Fitch, *Amer. Entomol.* 3 (1880):121-123.

[11] A.M. Fitch-Andrews to P.R. Uhler, 6 letters dated 23 May – 17 Oct.1879, file bMu 75.10.1, Museum of Comparative Zoology, Harvard University.

[12] H.B. Weiss, *The Pioneer Century of American Entomology* (New Brunswick, published by the author, 1936), p.219.

[13] Sanborn and Lintner, Account.

[14] J.G. Sanders, A review of the Coccidae described by Dr. Asa Fitch, *Proc. Entomol. Soc. Wash.* 12(1910):56-61.

[15] F.W. Goding, Fitch's types of N.A.Membracidae, *Can. Entomol.* 25(1893):171-172, 196.

[16] J.A. Lintner stated that the State Museum of Natural History, successor to the State Cabinet of Natural History, purchased four large hanging cases of insects from Dr. Fitch in 1874 (see Sanborn and Lintner, Account). I have been unable to confirm this statement.

[17] Anon., Insects, *Trans. N.Y. State Agric. Soc.* 17 (1858):373-377.

[18] Anon., Interesting to farmers. Our State Agricultural Society; Museum, *New York Weekly Tribune*, 19 May 1860:7.

[19] Diary, 17-26 Aug.1871, 4-7 Oct.1871, 1 Jan 1872, 4 Apr.1872; Sanborn and Lintner, Account.

[20] Laws of New York, 1888, Chapter 270.

[21] *ICZN*, Article 11(g)(i).

[22] *Ibid.*, Article 45(e)(i).

[23] *Ibid.*, Article 72(b).

[24] J.K. Barnes, The Membracidae and other Homoptera described by Asa Fitch, 1851, and Ebenezer Emmons, 1855: historical perspective and analysis, *J.N.Y.Entomol.Soc.* 92 (1984): 27-34; J.K. Barnes, Recently recognized types of some Homoptera described by Dr.Asa Fitch, *Psyche* 91(1984):133-139.

[25] W. D. Funkhouser, Types of Fitch's species of Membracidae, *Bull. Brooklyn Entomol. Soc.* 10(1915): 45-50.

[26] J. E. Keirans and J. K. Barnes, Lectotype designations for the ticks (Acari:Ixodoidea:Ixodidae) described by Asa Fitch, J. N.Y. Entomol. Soc. 95(1987):109-113.

1988

Bulletin No. 461
New York State Museum

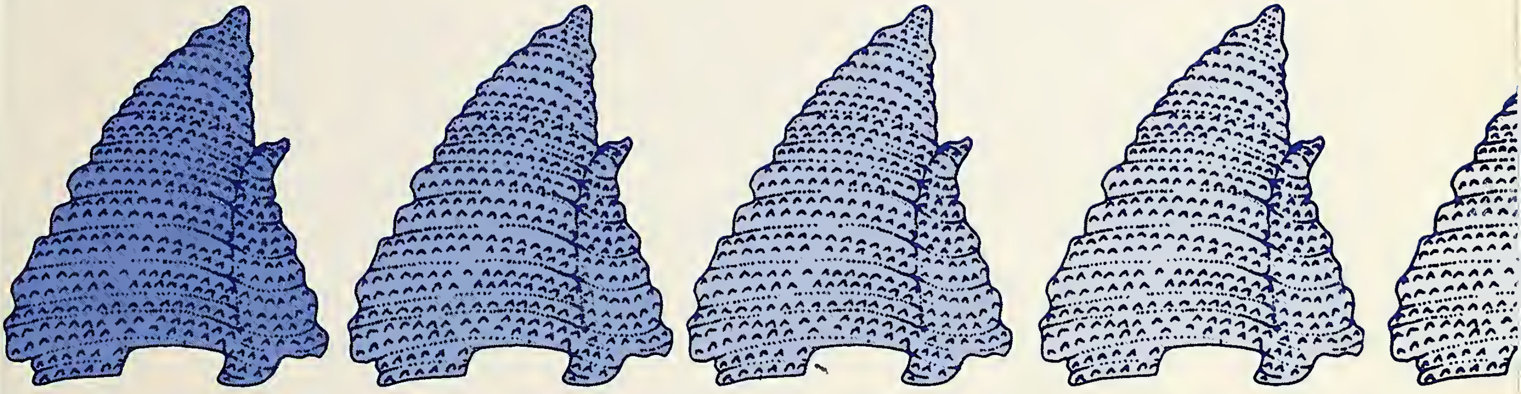
ISSN 0278-3355
ISBN 1-55557-006-2

Ed Landing
Editor

Bulletin Number 462 / New York State Museum

THE CANADIAN PALEONTOLOGY & BIOSTRATIGRAPHY SEMINAR

vorthella schodackensis
(Lochman)
fragment of the external
ior of an Early Cambrian
animal from eastern
lew York State, enlarged



PROCEEDINGS OF MEETING
September 26-29, 1986

Geological Association
of Canada

SMITHSONIAN
JUL 29 1988
LIBRARIES

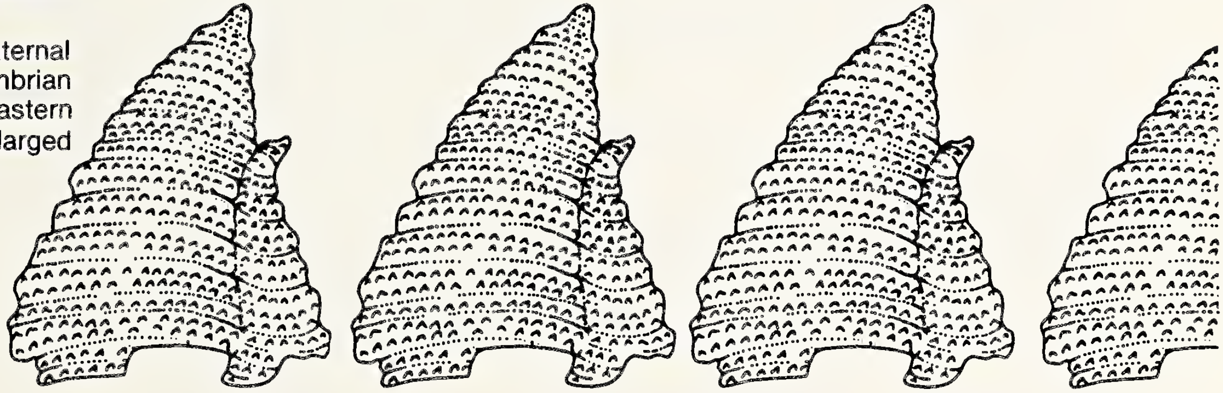
NEW YORK
THE STATE OF LEARNING

The University of the State of New York,
The State Education Department/Albany 12230

SMITHSONIAN
JUL 29 1988
LIBRARIES

THE CANADIAN PALEONTOLOGY & BIOSTRATIGRAPHY SEMINAR

Lapworthella schodackensis
(Lochman)
— fragment of the external
armor of an Early Cambrian
animal from eastern
New York State, enlarged



Ed Landing
Editor

Bulletin Number 462 / New York State Museum

PROCEEDINGS OF MEETING

September 26-29, 1986

Geological Association
of Canada

NEW YORK
THE STATE OF LEARNING

The University of the State of New York,
The State Education Department/Albany 12230

March 1988

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of The University

Martin C. Barell, *Chancellor,* B.A., I.A., LL.B.	Muttontown
R. Carlos Carballada, *Vice Chancellor,* B.S.	Rochester
Willard A. Genrich, LL.B.	Buffalo
Emlyn I. Griffith, A.B., J.D.	Rome
Jorge L. Batista, B.A., J.D.	Bronx
Laura Bradley Chodos, B.A., M.A.	Vischer Ferry
Louise P. Matteoni, B.A., M.A., Ph.D.	Bayside
J. Edward Meyer, B.A., LL.B.	Chappaqua
Floyd S. Linton, A.B., M.A., M.P.A.	Miller Place
Salvatore J. Sclafani, B.S., M.D.	Staten Island
Mimi Levin Lieber, B.A., M.A.	Manhattan
Shirley C. Brown, B.A., M.A., Ph.D.	Albany
Norma Gluck, B.A., M.S.W.	Manhattan
Thomas R. Frey, A.B., LL.B.	Rochester
James W. McCabe, Sr., A.B., M.A.	Johnson City
Adelaide L. Sanford, B.A., M.A., P.D.	Hollis

President of The University and Commissioner of Education
Thomas Sobol

Executive Deputy Commissioner of Education
Robert J. Maurer

Deputy Commissioner for Cultural Education
Carole F. Huxley

Assistant Commissioner for State Museum
Martin E. Sullivan

Director, Division of Research and Collections
Paul J. Scudiere

State Geologist and Chief Scientist, Geological Survey
Robert H. Fakundiny

The State Education Department does not discriminate on the basis of age, color, religion, creed, disability, marital status, veteran status, national origin, race, or sex in the educational programs and activities which it operates. Inquiries concerning this policy of equal opportunity and affirmative action should be referred to the Department's Affirmative Action Officer, Education Building, Albany, NY 12234. Phone (518) 474-1265.

CONTENTS

Preface IV

Program of Events 1

Schedule of Technical Sessions 2

Abstracts 4

Position Papers on Ordovician Chronostratigraphy 20

Conodont Biostratigraphy of Some Middle Ordovician Stratotypes in the Southern and Central Appalachians
Stig M. Bergström, John B. Carnes, Jack C. Hall, Wolfgang Kurapkat and Brian E. O'Neil 20

Graptolite-Based Correlation of Earliest Ordovician in Eastern North American Marginal Sequences with Coeval Successions in Northern China and Oslo, Norway
Bernd-Dietrich Erdtmann 33

The International Correlation of the Lower Part of the Ordovician and How it Should Influence Laurentian Chronostratigraphy
Richard A. Fortey 43

Cambrian-Ordovician Boundary in North America: Revised Tremdocian Correlations, Unconformities and "Glacioeustasy"
Ed Landing 48

Ordovician Series/Stages, Graptolitic Basinal Facies, Northern Yukon, Canada
Alfred C. Lenz 59

The Myth of a Eustatic Sea Level Drop near the Base of the Ibexian Series
Rolf Ludvigsen, Brian R. Pratt and Steven R. Westrop 65

The Gamachian Stage and Fauna 13
Alexander D. McCracken and Godfrey S. Nowlan 71

Relatively Chrono
Reuben J. Ross, Jr. 80

Constraints of Brachiopod Zoogeography on Correlation in the Late Ordovician and Early Silurian of North America
Peter M. Sheehan 80

Mohawkian and Cincinnatian Chronostratigraphy
Walter C. Sweet 84

Lower Ordovician Chronostratigraphy and Graptolite Biostratigraphy in Eastern Canada
S. Henry Williams 91

Field Trips 96

Field Trip A: Depositional Tectonics and Biostratigraphy of the Western Portion of the Taconic Allochthon, Eastern New York State
Ed Landing 96

Field Trip B: Upper Silurian to Middle Devonian Stratigraphy and Depositional Controls, East-Central New York
Edwin J. Anderson, Carlton E. Brett, Donald W. Fisher, Peter W. Goodwin, Gerry J. Kloc, Ed Landing, Richard H. Lindemann 111

Field Trip C: Stratigraphy and Sedimentology of the Chazy Group (Middle Ordovician) – Lake Champlain Valley
Stephen E. Speyer and Bruce W. Selleck 135

PREFACE

In keeping with a tradition as the major source of information on the geology of New York State and as an organization that has long attempted to promote the discovery and synthesis of paleontological data for use in geology, the New York State Geological Survey was pleased to host the 1986 Canadian Paleontology and Biostratigraphy Seminar. The Seminar is the annual meeting of the Paleontology Division of the Geological Association of Canada. The 1986 meeting of Canadian and American paleontologists from academic, governmental, and industrial institutions was the first held outside of Canada. This function was sponsored as part of the Sesquicentennial Celebration of the New York State Geological Survey. The James Hall Medal was presented to G. Arthur Cooper during the meeting in recognition of his contributions to the paleontology of New York State and to the science of paleontology.

It is hoped that this meeting and its published program will promote the distribution of new data and techniques in the study of ancient life and its environments. The utility of this information in applied geology is well expressed in the Abstracts, Position Papers, and Field Trip Guides. The Paleontology Collection of the New York State Museum has been made available to Seminar participants. Its use as a basic resource in research and as a primary repository for field data has been encouraged.

The New York State Museum provided facilities for the meeting. Partial financial support for the meeting was provided by the Geological Survey of Canada, the Paleontology Division of the Geological Association of Canada, and E. Landing. L. V. Rickard functioned as editor of the Program. J. B. Skiba provided drafting support and M. D. Fluewelling typed the program. Contributors of abstracts and manuscripts, reviewers of the Position Papers, and session chairpeople are gratefully thanked for their efforts.

THE CANADIAN PALEONTOLOGY AND BIOSTRATIGRAPHY SEMINAR/ SESQUICENTENNIAL CELEBRATION OF THE NEW YORK STATE GEOLOGICAL SURVEY

PROGRAM OF EVENTS

THURSDAY, SEPTEMBER 25, 1986

Mixer for early arrivals	2000-2300 Hilton Hotel

FRIDAY, SEPTEMBER 26, 1986

Field Trip A (Taconic geology) and Field Trip B (Silurian-Devonian geology)	0830-All Day Depart from Museum
Smoker	1900-2300 R. H. Fakundiny Residence

SATURDAY, SEPTEMBER 27, 1986

Registration	0800-0900 Auditorium
Precambrian and Cambrian Paleontology	0900-1100 Auditorium
Key-Note Presentation	1130-1150 Auditorium
Stratigraphic and Applied Paleontology	330-1445 Auditorium
Evolutionary and Systematic Paleontology	1500-1600 Auditorium
Working Group on North American Ordovician Chronostratigraphy: A Roundtable Discussion	1620-1900 Auditorium
Dinner and Presentation of James Hall Medal to G. Arthur Cooper	2000-2350 Sign of the Tree Restaurant

SUNDAY, SEPTEMBER 28, 1986

Poster Session	0900-1100 Meeting Room D
Invited Presentation	1110-1200 Auditorium
Paleoecology and Paleoenvironments	1330-1445 Auditorium
Paleontology Division (GAC), Business Meeting	1500-1600 Auditorium
Departure for Field Trip C (Middle Ordovician)	1800

MONDAY, SEPTEMBER 29, 1986

Field Trip C	0830-All Day Depart from Hotel

SCHEDULE OF TECHNICAL SESSIONS

SATURDAY, SEPTEMBER 27, 1986

PRECAMBRIAN AND CAMBRIAN PALEONTOLOGY

Godfrey S.Nowlan and Christopher C. Ryley, Presiding

Guy M. Narbonne*, **Hans J. Hofmann**: Vendian Macrobiota of the Wernecke Mountains, Yukon, Canada 0900

Alison P. Benus: Sedimentology and Occurrences of Soft-Bodied Fossils in the Mistaken Point Formation (Late Precambrian, Avalon Zone, Eastern Newfoundland) 0920

Mark A. S. McMenamin: Lower Cambrian Mickwitziid Brachiopods 0940

Ed Landing*, **Guy M. Narbonne**, **Paul Myrow**, **Alison P. Benus**, **Michael M. Anderson**: A Sub-Trilobitic Lowest Cambrian Series for Avalon: The Etcheminian 1000

Rolf Ludvigsen: Trilobite Biostratigraphic Models and the Paleoenvironment of the Burgess Shale (Middle Cambrian), Yoho National Park, British Columbia 1020

Stephen R. Westrop*, **Rolf Ludvigsen**: Spatial Variability in Trilobite Mass Extinction Patterns Across an Upper Cambrian Stage Boundary 1040

Coffee Break 1100

KEY-NOTE PRESENTATION

Richard M. Bambach: Evolutionary Cycles 1130

STRATIGRAPHIC AND APPLIED PALEONTOLOGY

Donald W. Fisher and Daniel Goldman, Presiding

David J. Kennedy: Conodont Alteration Index (CAI): Three Examples of its Use in Lower and Middle Paleozoic Tectonostratigraphy in Southeastern Australia 1330

Alexander D. McCracken*, **Godfrey S. Nowlan**: Correlation of Upper Ordovician Strata on the Basis of Conodonts 1345

Pierre J.Lespérance: Stratigraphy of the Upper Gaspé Limestones (Early Devonian) of Eastern Gaspé, Québec 1400

Christopher C. Ryley*, **Lars E. Fahraeus**: Upper Triassic Conodonts from the Mamonia Complex of Cyprus 1415

Russell L. Hall: New Lower Jurassic Ammonites from the Fernie Formation, Southern Canadian Rocky Mountains 1430

Coffee Break 1445

EVOLUTIONARY AND SYSTEMATIC PALEONTOLOGY

Alison P. Benus and Alexander D. McCracken, Presiding

Robert Titus: An Evolutionary History of the Genus *Ectenocrinus* from a Study of the Biostratigraphy of its Columnal Forms 1500

James D. Eckert: Late Ordovician Extinction – Early Silurian Radiation of Pelmatozoan Echinoderms of North America 1515

Daniel Goldman: Ambocoelid Brachiopods of Western New York	1530
James W. Scatterday: The Middle Devonian Brachymetopid Trilobite *Australosutura gemmaea* (Hall & Clarke, 1888), Close Relatives, Descendants, and Ancestors	1545
Coffee Break	1600

WORKING GROUP ON NORTH AMERICAN ORDOVICIAN CHRONOSTRATIGRAPHY: A ROUNDTABLE DISCUSSION

John E. Repetski and Thomas Bolton, Presiding	1620

SUNDAY, SEPTEMBER 28, 1986

POSTER SESSION

Authors will be present from 0900 to 1100 hours

Markes E. Johnson: Historical Development of Paleogeographic, -Biogeographic, and -Bathymetric Maps of Silurian Platform Seas for North America, Including a New Interpretation	Booth 1
Godfrey S. Nowlan, Christopher R. Barnes: Conodont Colour Aleration Data from the St. Lawrence Platform and Appalachian Orogen in Eastern Canada	Booth 2
Allen A. Petryk: Correlation of the Upper Ordovician and Lower Silurian Stratotypes of Britain and Parastratotypes of Anticosti Island, Canada	Booth 3
Ronald K. Pickerill, Denis Fillion: *Cruziana* Stratigraphy of the Lower Ordovician Bell Island and Wabana Groups, Conception Bay, Eastern Newfoundland	Booth 4
David M. Rudkin, Kevin Brett: Trilobite Fauna of the Upper Bobcaygeon Formation (Middle Ordovician, Kirkfieldian), South Ontario	Booth 5

INVITED PRESENTATION

Carlton E. Brett*, Gordon C. Baird: Cyclic and Episodic Sedimentary Processes in Middle Devonian Epeiric Seas: Tempestites, PAC's and Cyclothems Reconsidered	1110

PALEOECOLOGY AND PALEOENVIRONMENTS

Mark A. S. McMenamin and Brian R. Pratt, Presiding

Lin Bea-Yeh*, Carlton E. Brett: Paleoenvironments and Depositional History of the Williamson-Willowvale Shales, Silurian, Western New York	1330
Robert J. Elias*, Robert J. McAuley, Blair W. Mattison: Directional Orientations of Solitary Rugose Corals	1345
David M. Linsley: Autecology, Based on Mode of Preservation, of Some Middle Devonian Bivalves	1400
James E. Sorauf: Rugose Corals from Upper Devonian Frasnian Strata of South-Central and Southwestern New York State	1415
David W. Steadman*, Norton G. Miller: Paleoecology of the Late Quaternary Hiscock Site, Genesee County, New York: An Initial Report	1430

ABSTRACTS OF PAPERS PRESENTED AT THE 1986 CANADIAN PALEONTOLOGY AND BIOSTRATIGRAPHY SEMINAR/ SESQUICENTENNIAL CELEBRATION OF THE NEW YORK STATE GEOLOGICAL SURVEY

Additional information on the oral and poster presentations summarized in these abstracts should be obtained by contacting the authors.

SEDIMENTOLOGY AND OCCURRENCES OF SOFT-BODIED FOSSILS IN THE MISTAKEN POINT FORMATION (LATE PRECAMBRIAN, AVALON ZONE, EASTERN NEWFOUNDLAND)

BENUS, Alison P., Dept. of Earth Sciences, Memorial University, St. John's, Nfld. A1C 3X5

The late Precambrian (Ediacaran) fossil-bearing Mistaken Point Formation of the Conception Group crops out in coastal localities of the Avalon Zone, eastern Newfoundland. This deep-water siliciclastic sequence was deposited in an outer fan environment in proximity to a volcanic terrane.

Preliminary analysis of the upper portion of the Mistaken Point Formation at its type locality and at a more western locality (St. Shotts) indicates the presence of two dominant facies. The first consists of arkosic arenites (mostly Ta) overlain by decimeter thick structureless mudstones (Te). These "Facies A" turbidites (0.5-1.0 m thick) alternate with thin (1-2 cm) mudstone layers with discontinuous laminations. Such mudstones often contain mm to cm volcaniclastic bands as well as fossiliferous horizons and are interpreted as the products of hemipelagic deposition. The preservation of anomalously sharp contacts between the turbidite and overlying hemipelagic mudstones probably was favored by the lack of bioturbation in these Precambrian deposits. Amalgamation and convolute lamination of the arenites often occur within Facies A.

"Facies B" differs from "Facies A" in that the turbidites are thinner (ca. 10 cm) and consist of relatively finer-grained arenites (Ta or Tc) that are overlain by structureless Te mudstone. Thick-bedded, sheet-like, unchannelized(?) sandstone lobes and thin-bedded lobe-fringe deposits of the Mistaken Point Formation are compatible with deposition in Mutti's (1985) "Type 1" turbidite system (=high efficiency fan).

Soft-bodied Ediacaran metazoans of the Mistaken Point differ from practically all other known Ediacaran faunas in that they occur in a deep water as opposed to a shallow marine environment. These dominantly *in situ* organisms have been preferentially preserved on bedding planes within hemipelagic layers, below volcanic ash beds, and below possible contourites. Normal turbidite activity was sufficient to erode the metazoans. Preservation of these fossils as external molds that are deeply impressed in underlying mudstone suggests that these "soft bodied" organisms had a tough leathery integument and had a body plan that was more inflated than is generally believed in reconstructions of Ediacaran metazoans.

CYCLIC AND EPISODIC SEDIMENTARY PROCESSES IN MIDDLE DEVONIAN EPEIRIC SEAS: TEMPESTITES, PAC's AND CYCLOTHEMS RECONSIDERED

BRETT, Carlton E., Dept. of Geological Sciences, University of Rochester, Rochester, NY 14627 and BAIRD, Gordon C., Dept. of Geosciences, SUNY College at Fredonia, Fredonia, NY 14603

The Middle Devonian (Givetian) Hamilton Group in western and central New York, composed largely of fossil-rich, marine shelf and slope facies, is subdivisible into repetitive sequences of lithologies and faunas of several scales. Observed patterns of facies fluctuation can be explained as the interaction between cyclic and noncyclic (episodic) processes of varying temporal magnitude. Geologically instantaneous events, such as storms, generated distinctive beds (tempestites) that display an onshore-offshore proximality spectrum. Such onshore-offshore storm beds allow a further subdivision of the section as well as an independent parameter for assessing the relative depth significance of cyclic facies. Major cycles, best exemplified by the Centerfield Member in western New York, are subsymmetrical 3-5 m-thick packages which display opposing facies spectra about medial limestone beds that are analogous to "upper limestones" of Pennsylvanian cyclothems. The center of each cycle marks a regressive maximum which grades vertically to black shale or dark gray mudstone deposits, corresponding to cyclothemic "core shales." These widespread units appear to be allocyclic in nature and approximate 5th or 6th order transgressive-regressive (T-R) cycles that are recognized by others. This scale of cyclicity is based upon average unit thickness relative to the encompassing, well-zoned, Hamilton sequence.

Correlations show that most key regressive events, marked by limestones in western New York, are expressed by equivalent siltstone or fine sandstone units in central New York. We find, however, that most cycles, which are nearly symmetrical in western New York, grade eastward into upward-coarsening hemicycles, resembling "PAC's" (punctured aggradational cycles). These asymmetric cycles apparently reflect rapid sediment aggradation to limits imposed by wave energy in a region of abundant sediment supply. The additive effects of relative sea level drop and aggradation led to shallowing of the sea floor to near wave base. Further shallowing was accompanied by winnowing and bypass of fine-grained sediments that produced condensed, capping deposits of coarser silt-sand, reworked shells, and commonly, phosphatic nodules ("roof beds"). Ensuing sea level rises were accompanied by initial sediment starvation followed by sedimentation in deeper water.

Hence "PAC's" grade laterally into thin, but symmetrical cycles. Both are local responses to the same, probably allocyclic, sea level fluctuations. We suggest that the PAC motif is facies-controlled, being restricted to shallow shelf settings with relatively high rates of sediment input.

Finally, another regional variable, superimposed on allocyclic patterns, is dynamic, tectonic shifting of one or more major depocenters throughout Middle to Late Devonian time. As a result, areas of deepest water and related depocenters display westward migration.

LATE ORDOVICIAN EXTINCTION – EARLY SILURIAN RADIATION OF PELMATOZOAN ECHINODERMS OF NORTH AMERICA

ECKERT, James D., Dept. of Geological Sciences, University of Rochester, Rochester, NY 14627

Abundant and diverse faunas in the Bromide Formation and Lebanon Limestone record an early Caradocian radiation of pelmatozoans in North America. Blastozoans, poorly represented in these faunas, subsequently declined while their European counterparts diversified. Following an acme in the Middle Caradocian (Trentonian), diversity of crinoids declined gradually through most of the Ashgillian. In eastern North America, this decline is correlated with replacement of carbonate lithosomes by regressive, dominantly clastic facies derived from the Taconic orogen. Pelmatozoan extinction rates rose abruptly in the late Ashgillian (*A. divergens* conodont zone) when all cincinnaticrinids, reteocrinids, pleurocystitids, most homocrinids, and several genera of monobathrid camerates and short-armed cladid inadunates became extinct, including virtually all echinoderm taxa in the Cincinnati Province. Essentially simultaneous extinction of many diploporitans occurred in Europe and was completed prior to the Hirnantian Stage. If estimates that the Late Ordovician glacial maximum spanned only a portion of the Hirnantian are correct, extinction of Late Ordovician echinoderms preceded this event by up to several million years, suggesting that species-area effects accompanying maximum glacioeustatic drawdown were not significant in their extinction. Cooling of epeiric seas preceding Late Ordovician glaciation may have contributed to this extinction, perhaps by inhibiting reproduction.

Latest Ordovician (Gamachian) cratonic carbonates of the Red River-Stony Mountain Province contain low diversity pelmatozoan assemblages from which Silurian taxa radiated. Earliest Silurian (Rhuddanian) shelf carbonates and coextensive prodeltaic siliciclastics of southern Ontario, Canada, contain low-diversity assemblages of crinoids with a markedly Ordovician aspect. These relict faunas persisted into the Idwian and Fronian of the northern Appalachian Basin where physically stressed, uncrowded conditions acted as a refuge in which evolutionary rates were slow. Accelerated diversification of pelmatozoans in the Silurian coincided with deposition of platform carbonates representing transgressive peaks (Brassfield Formation, Hopkinton Dolomite) in the middle and late Llandovery. A large, new crinoid faunule from the *Pentamerus*-bearing Wolcott Limestone (late Llandovery, C4-C5) of western New York consists of ancestral Wenlockian forms that coexisted with relict Ordovician taxa. The relict Ordovician lineages were largely exterminated during the extensive late Llandovery (C6) transgression which facilitated emigration of previously endemic North American crinoids to Europe in the latest Llandovery and earliest Wenlockian coincident with a smaller counter-invasion of European blastozoans.

DIRECTIONAL ORIENTATIONS OF SOLITARY RUGOSE CORALS

ELIAS, Robert J., MCAULEY, Robert J.,[1] and MATTISON, Blair W.,[2] Dept. of Earth Sciences, University of Manitoba, Winnipeg, Man. R3T 2N2

Unattached solitary rugose corals lying parallel to bedding are common in many Ordovician and younger Paleozoic units, but their directional orientations have seldom been examined. Interpretations based on occurrences in North American Upper Ordovician and Lower Silurian strata provide a foundation for such studies. Non-random patterns resulted from preferred orientation with respect to directed water flow. They indicate transportation, rather than biologic orientation if it can be shown that the corals were not preserved in life position or were abraded to a significant degree before burial. Transported, slightly curved specimens having trochoid to ceratoid form were aligned parallel to currents with the apex generally upstream and/or were oriented perpendicular to flow with the apex facing either way but pointing slightly upstream. Therefore, unimodal patterns, bimodal patterns with equal peaks that are opposite one another but slightly skewed, and trimodal patterns that are a combination of these can be used to determine paleocurrent directions. A possible bimodel pattern with equal and directly opposite peaks has been observed for subcalceoloid corals, which were likely aligned parallel to flow. It suggests a line of water movement, but the direction of the flow is uncertain. Random distributions do not necessarily indicate low energy environments. They could have resulted from changes in flow direction during the time in which the sampled stratigraphic interval was deposited or from the effects of bioturbation on initially non-random patterns.

Directional patterns of solitary rugose corals are of value in paleoecology (recognition of transported assemblages) and basin analysis (determination of paleocurrent directions). They may also prove to be useful in making paleoenvironmental reconstructions (type of water motion, nature of substrate), if the reasons for different orientation patterns can be established with experimental work and additional data from the geologic record.

---

[1] Present address: Department of Geology and Geophysics, University of Calgary, Calgary, Alberta T2N 1N4

[2] Present address: Department of Geology, University of Alberta, Edmonton, Alberta T6G 2E3

AMBOCOELIID BRACHIOPODS OF WESTERN NEW YORK

GOLDMAN, Daniel, Dept. of Geological Sciences, State University of New York at Buffalo, 4240 Ridge Lea Road, Amherst, NY 14226

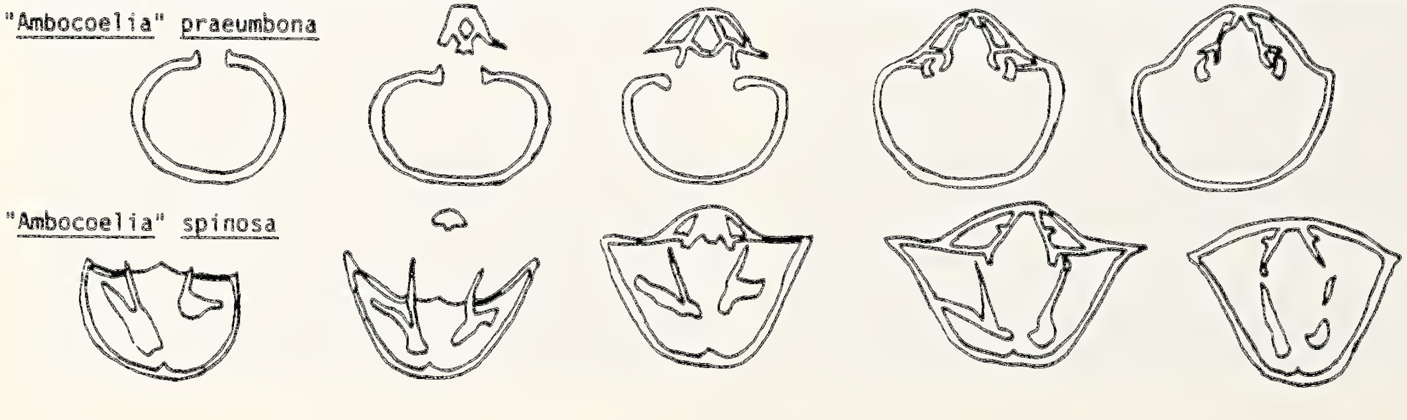
Several species of the brachiopod genus *Ambocoelia* Hall occur in the Hamilton Group (Middle Devonian) of western New York State. Current research into the internal morphology and phylogenetic relationships of these species is producing interesting new information. The original generic assignments of two species, "*Ambocoelia*" *praeumbona* and "*Ambocoelia*" *spinosa* were based on external features alone. The internal morphology of these species indicates that they are not members of the genus *Ambocoelia*.

James Hall described the genotypic characters of *Ambocoelia* in 1860 based on the species *Orthis umbonata* Conrad. A brief summary of these characters is as follows: shell shape is plano-convex to concavo-convex, with the hinge line equal to the greatest width of the shell. The brachial valve is flat to concave, has a large bilobed cardinal process, well developed crural plates, and an anteriorly positioned adductor muscle field. The pedicle valve is deeply convex with a strongly incurved umbo. Dental plates are lacking. *Ambocoelia umbonata* occurs throughout the Hamilton Group.

"*Ambocoelia*" *praeumbona* differs markedly from *A. umbonata*. "*Ambocoelia*" *praeumbona* is bi-convex, has a brachythyrid hinge line, and is much larger than *A. umbonata*. Internally it has a striated cardinal process which is supported by two small plates that are attached to the floor of the brachial valve. The dental sockets are "elevated" on high crural plates and are formed by inner and outer socket ridges (*A. umbonata* has "sessile" sockets formed by an inner socket ridge and the valve wall). The brachial valve does not have the same anteriorly positioned adductor muscle field as in *A. umbonata*. The pedicle valve lacks dental plates, has small teeth and an open delthyrium bounded by thin ridges. "*Ambocoelia*" *praeumbona* occurs in the upper part of the Windom Shale member of the Moscow Formation. Based on comparisons with other genera of the family Ambocoeliidae, "*Ambocoelia*" *praeumbona* may be most appropriately placed in the genus *Emanuella* Grabau.

"*Ambocoelia*" *spinosa* is plano-convex to slightly biconvex, with the pedicle valve being greatly inflated. The pedicle umbo is more erect, and there is a much higher interarea than in *A. umbonata*. The pedicle valve also has a deep sulcus which causes a pronounced plication in the commissure. The greatest external difference is the spine covered shell of "*A.*" *spinosa*.

Internally, the brachial valve has a small triangular cardinal process, and "sessile" sockets. The pedicle valve has reduced dental plates which support large teeth. The dental plates bound the delthyrium as thin ridges and then continue internally but do not attach to the floor of the valve. Dental plates are of generic importance in articulate brachiopods, and their presence in "*Ambocoelia*" *spinosa* may warrant the establishment of a new genus. "*Ambocoelia*" *spinosa* occurs in the Kashong Shale member of the Ludlowville Formation.



NEW LOWER JURASSIC AMMONITES FROM THE FERNIE FORMATION, SOUTHERN CANADIAN ROCKY MOUNTAINS

HALL, Russell L., Dept. of Geology and Geophysics, University of Calgary, Calgary, Alta T2N 1N4

The Fernie Formation in the southern Canadian Rocky Mountains consists of sediments deposited on the western margin of cratonic North America throughout most of the Jurassic Period; as such, its provenance, stratigraphy and faunas are all clearly tied to the North American craton.

The angular unconformity underlying the Fernie Formation intersects successively older units as it is traced eastward toward the craton; in westerly parts of the overthrust belt the Fernie lies with local disconformity on Triassic units whereas farther east it overlies Late Paleozoic carbonates. The age of these basal Fernie sediments varies; at most localities where they can be dated, the arietitid ammonites *Arietites* and *Arnioceras* give an Early Sinemurian age (Bucklandi-Semicostatum Zones), but a new fauna at Bighorn Falls with *Epophioceras* and *Asteroceras stellare* (J. Sowerby) indicates an early Late Sinemurian age (Obtusum Zone).

In Toarcian time, a second major transgression of the "Fernie sea" occurred, now represented by widespread occurrences of finely laminated, black "paper shales" of the Poker Chip Shale. Lithologies, faunas and their modes of preservation all indicate deposition under anaerobic conditions. Ammonites from this unit on Bighorn Creek include *Dactylioceras*, *Harpoceratoides*, *Hildaites* and *Harpoceras subplanatum* (Oppel). Occurrence of these genera together presents difficulties in establishing firm and precise correlations with known European sequences but indicates correlation generally with the Falcifer or lowest Bifrons Zones. At Fording River, another new fauna with *Esericeras* and *Denckmannia* indicates correlation with the lower part of the Late Toarcian Levesquei Zone.

Ammonite faunas during both Sinemurian and Toarcian times were cosmopolitan; a fact which is emphasized by the close taxonomic affinities of these new faunas from western Canada with European forms.

HISTORICAL DEVELOPMENT OF PALEOGEOGRAPHIC, -BIOGEOGRAPHIC, AND -BATHYMETRIC MAPS OF SILURIAN PLATFORM SEAS FOR NORTH AMERICA, INCLUDING A NEW INTERPRETATION

JOHNSON, Markes E., Dept. of Geology, Williams College, Williamstown, MA 01267

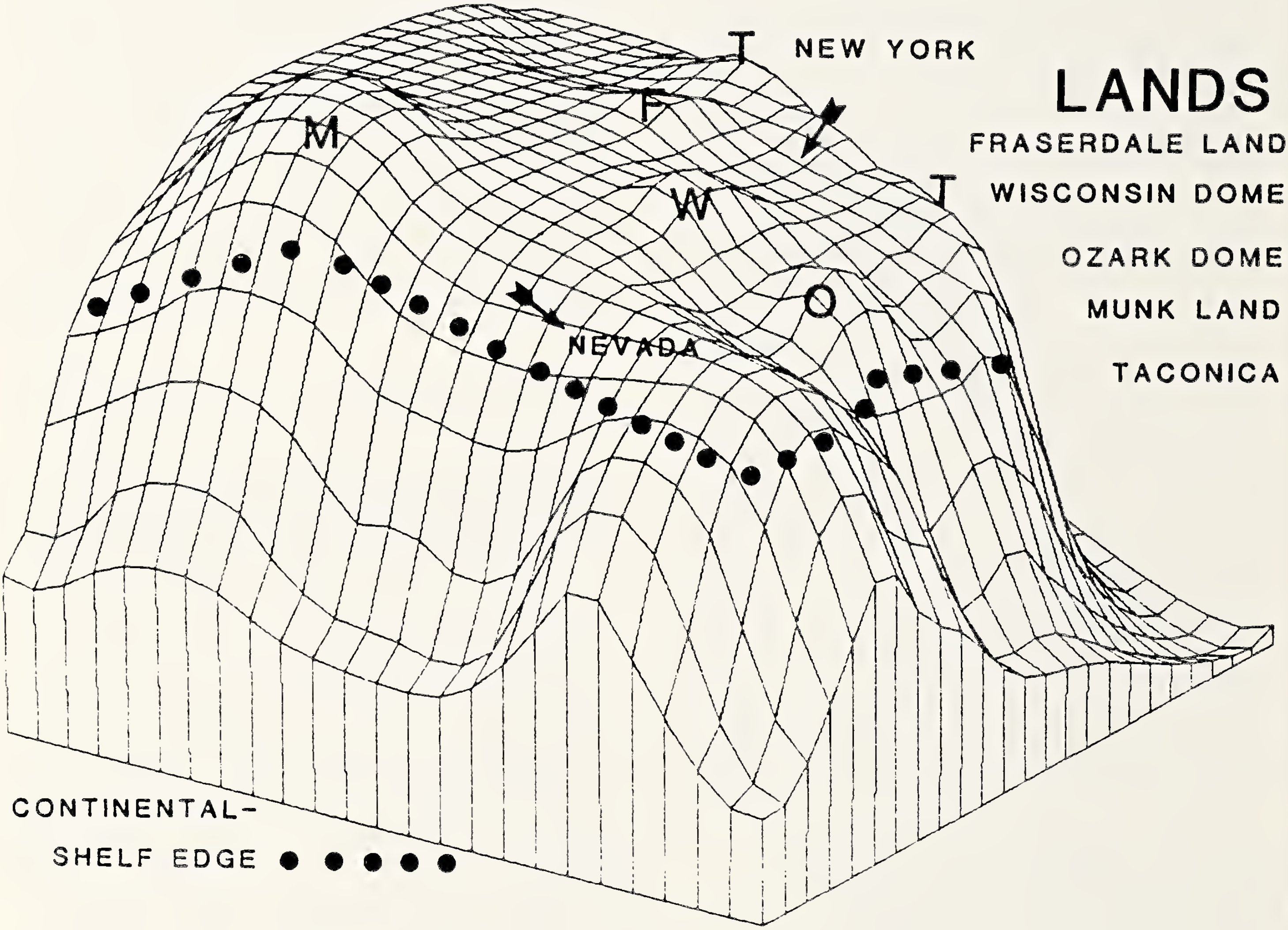
The earliest paleogeographic map of "Silurian" North America was drafted by Thomas Chamberlin in 1881, but it covers what we would now recognize as an Ordovician time frame. Nonetheless, his map is interesting because it represents the first restoration of the "Appalachian Highlands" and interprets the Wisconsin and Ozark domes as small lowlands. Stuart Weller (1898) combined the first detailed distribution map of Silurian strata with his version of paleogeography. He recognized strong faunal similarities between Europe and North America and proposed that faunal communication between the two continents circumvented a major Atlantic borderland by way of a seaway through Hudson Bay and the North Polar regions.

During the early 1900's, Charles Schuchert attempted to systematically chart a whole series of Phanerozoic maps. The most advanced stage of his work was posthumously published as an atlas in 1955. It includes 10 time planes for the Silurian Period. Despite the huge data base he assembled for these reconstructions, the final product excluded information on large parts of the Williston and Hudson Bay basins. Also in 1955, Thomas Amsden produced a sophisticated lithofacies map of Lower Silurian strata in central and eastern North America. His map goes far beyond Schuchert's primary goal of distinguishing land from marine environments.

In 1970 Ziegler and Boucot presented the first biogeographic maps of Silurian marine communities in North America. Four maps are devoted to the Llandovery Epoch and one each cover the Wenlock and Ludlow-Pridoli epochs. These maps focus on the kinds of depth-associated communities previously defined and mapped in Wales and the Welsh Borderland by Ziegler (1965) and Ziegler, Cocks, and Bambach (1968). Because the biogeographic maps of Ziegler and Boucot are keyed to fossil assemblages representing the preservable portion of depth-associated communities, the maps are also the first bathymetric charts of North American Silurian seas.

For the last several years, I have been working on a revised series of maps for the Llandovery Epoch of North America. The accompanying figure represents a computer-generated interpretation of the Silurian craton's topographic-bathymetric surface (with high vertical exaggeration). The line of sight looks towards the present east from Nevada to New York but the view excludes that part of North America above the present latitude of 65 degrees north. The major depositional basins are situated in low-lying regions amongst the various land areas shown as protruding "hummocks." The Reelfoot, East Iowa, and North Kansas basins, for example, ring the Ozark Dome (marked by an "O"). The Williston Basin occurs on the flank of a newly identified land area named Munk Land (marked by an "M"). I believe this configuration was fairly stable through most of the Early Silurian.

During peak episodes of continental flooding, communities dominated by populations of stricklandiid and pentamerid brachiopods thrived in the lowest bathymetric depressions on the craton. Size-graded fossil green algae associated with these communities suggest water depth in the deepest regions never exceeded 100 m. At other times during maximum continental exposure, stromatolitic and coral-stromatoporoid communities occupied the same low regions. Water depth on the craton probably did not exceed 30 m and large regions must have sustained even shallower Bahamian-type facies. Biogeographic-bathymetric maps representing both extremes in the Silurian sea-level cycle will be presented: one for the early Telychian high-stand in sea level and another for the late Telychian low-stand in sea level.



Topographic-Bathymetric Surface of the North American Craton in Mid-Llandovery Time

CONODONT ALTERATION INDEX (CAI): THREE EXAMPLES OF ITS USE IN LOWER AND MIDDLE PALEOZOIC TECTONOSTRATIGRAPHY IN SOUTHEASTERN AUSTRALIA

KENNEDY, David J., Dept. of Geological Sciences, Brock University, St. Catharines, Ont. L2S 3A1

Three examples showing how conodont alteration indices (CAI) can be used to refine the geological history of sedimentation and tectonics of an area are drawn from the geology of southeastern Australia.

The southern end of the Lachlan fold belt in Tasmania and Victoria consists of a suite of Cambrian eugeoclinal sediments and volcanics with some ophiolites, Ordovician deep water clastics in Victoria, and a transgressive sequence of conglomerates (derived from Precambrian metamorphics), sandstones and a thick platformal sequence of shallow-water carbonates in Tasmania. Crustal instability gave rise to thick, variable siliciclastic sequences in the Silurian to Middle Devonian but lenticular carbonate bodies developed in places. Three orogenies affected Victoria (in particular) during the Late Ordovician-Early Devonian. The Middle Devonian Tabberabberan Orogeny resulted in massive intrusions of granites and extensive folding in much of southeastern Australia.

The first example in the use of CAI is from the Cape Liptrap Peninsula, southeastern Victoria. The Waratah Bay Axis consists in the west of Middle Devonian turbidites of the Liptrap Formation. A major fault, the Waratah Bay Fault, separates the formation from a sequence to the east of Cambrian greenstones, the Lower Ordovician Digger Island Formation (limestones and mudstones) and two Devonian limestone units, the Waratah and Bell Point Limestones. A fault, previously regarded as "insignificant", separates the Ordovician and Devonian strata. The Axis commonly has been interpreted as a tectonic "high" through its history based primarily on the presence of shallow-water limestone units. The CAI of conodonts from the Ordovician Digger Island are brown (CAI = 2; 60-140° C) and those of the Devonian are black (CAI = 5; 300-400°C). Thus, the Devonian units have been subjected to much greater thermal metamorphism, and the implication is that the contact with the Ordovician strata is a major thrust.

The second example is of thermally immature (CAI = 1; 80°C) Silurian conodonts from a pink biosparite boulder in the Permian Wynyard Tillite, northwestern Tasmania. Two aspects make this example unique. Firstly, carbonates in the clastic Silurian of Tasmania are almost nonexistent and unlike the boulder. Thus, the source is anomalous. Secondly, the boulder escaped the regional metamorphism of the mid-Devonian Tabberabberan Orogeny which affected most earlier strata in Tasmania as well as any burial metamorphism from Permian to Recent times, and heating during the Jurassic (dolerites) and Tertiary (basalts).

The third example is of thermally-mature black Ordovician conodonts (CAI = 5) which have been reworked into the mid Lower Devonian (Praguian) Point Hibbs Limestone on the far west coast of Tasmania. The Point Hibbs Limestone contains conodonts of (CAI = 1.5; 50-90°C). Thus, the orogeny which caused the alteration must have occurred in pre-Praguian time. However, in western Tasmania, sedimentation continued into Early Devonian time. Thus, orogenic activity is confined to a short period in late Lochovian to early Praguian time, a period of a few million years. This orogenic activity is earlier than the activity of the Tabberabberan Orogeny (Middle Devonian) which affected north-central and eastern Tasmania.

A SUB-TRILOBITIC LOWEST CAMBRIAN SERIES FOR AVALON: THE ETCHEMINIAN

LANDING, Ed, New York State Geological Survey, The State Education Dept., Albany, NY 12230; NARBONNE, Guy M., Dept. of Geological Sciences, Queen's University, Kingston, Ont. K7L 3N6; MYROW, Paul, BENUS, Alison P., and ANDERSON, Michael M., Dept. of Earth Sciences, Memorial University, St. John's, Nfld. A1B 3X5

The geographically separated and environmentally distinct Siberian, Avalonian, South China, East Baltic and Laurentian platforms may be regarded as faunal realms with locally appropriate biostratigraphic and stage sequences in the earliest Cambrian. Detailed correlations of the high latitude Avalonian "Platform" lowest Cambrian (coastal eastern Canada and the northeastern U.S., central England, Normandy) with the well documented, approximately coeval, tropical Siberian sequences (Tommotian and Atdabanian Stages) is not possible. Avalonian sequences lack the archaeocyathids that define and provide a zonation for these Siberian stages, have a particularly late first-appearance of dissimilar trilobites, and have very long stratigraphic ranges for the few small shelly species common to the two realms. The stage-level units that have been defined on the Siberian and South China platforms are based on faunas from carbonate platform sequences that are very unlike those from the mixed siliciclastic-carbonate environments of Avalon. Portions of the Avalonian lowest Cambrian cannot be designated "Tommotian" or "Atdabanian" because Avalonian faunas can be used to establish only approximate or even questionable correlations at the stage level. In particular, present evidence suggests that no small shelly species are limited to the Tommotian and Meischucunian stages because they range higher into Atdabanian and Atdabanian-equivalent units. In a sense, correlations using small shelly remains often establish the Tommotian equivalency of local sequences on the basis of negative evidence.

Recent work reinforces the appropriateness of G. F. Matthew's "Etcheminian" as a series-level unit corresponding to the sub-trilobitic portion of the Avalonian Lower Cambrian. The original definition of the "Basal Series" and "Etcheminian" (1889, 1899) included siliciclastics with brachiopods and the trace fossils *Didymaulichnus* and *Rusophycus* (Ratcliffe Brook Formation) that occurred below a quartz arenite unit (Glen Falls Quartzite) in southern New Brunswick. This interval is the Chapel Island Formation and Random Quartzite in eastern Newfoundland.

Cambrian-aspect traces (e.g. *Phycodes pedum*, *Skolithos*, and *Monomorphichnus*) first appear at the base of Member 2 of the Chapel Island Formation. Shoaling and the development of limestones in Member 4 are linked to the first appearance of a Tommotian-aspect small shelly fauna (*Aldanella*, *Anabarites*, *Camenella*, *Eccentrotheca*). Small shellys disappear with further shoaling into the Random Quartzite but reappear with the disconformable onlap of the Bonavista Formation. Atdabanian-aspect forms (*Rhombocorniculum*, "*Hyolithes*" *bayonet*, *Pelagiella*) appear in the upper Bonavista Formation and lower Smith Point Limestone although all small shellys from the Chapel Island persist into these upper Etcheminian Stage units. The Etcheminian ends in New Brunswick, Cape Breton Island, and eastern Newfoundland at an unconformity. A fauna characterized by trilobites and, locally, ostracods accompanies the strongly diachronous onlap of the post-Etcheminian Lower Cambrian.

The significance of the Etcheminian series lies in the fact that it can serve as a lowest Cambrian small shelly fossil-based stage in Avalon. Trace fossils from the Etcheminian are more cosmopolitan and the Etcheminian may be globally recognizable in siliciclastic facies.

STRATIGRAPHY OF THE UPPER GASPÉ LIMESTONES (EARLY DEVONIAN) OF EASTERN GASPÉ, QUEBÉC

LÉSPERANCE, Pierre J., Dépt. de Géologie, Université de Montréal, Montréal, Qué. H3C 3J7

The upper five divisions of the Gaspé Limestones of Logan (1863), (#4-8) of the Forillon Peninsula of northeastern Gaspé, were subsequently divided (Ami and others, 1900) into the Cap Bon Ami (#4, 5, 6) and Grande Greve Formations (#7, 8), and thence into five members (Russell, 1976). The Quay Rock Member (#4) is a limestone that extends only 35 km inland and is lithologically different from the three younger members while the Cape Road Member (#5) is a terrigenous unit. The Upper Gaspé Limestones consequently have been separated from the predominantly terrigenous lower part, and considered to be composed of the Forillon (#6), the Shiphead (#7) and Indian Cove (#8) Formations (Lespérance, 1980) (formerly members of Russell, 1976). They are composed predominantly of siliceous limestones, locally very fossiliferous, but previous tabulations (Clarke, 1908) are suspect because of correlations of fossiliferous levels of the Shiphead with the Indian Cove of the Forillon Peninsula.

This three-fold division of the Upper Gaspé Limestones extends southward to Percé (Forillon Formation of Percé Rock and other nearby strata) and westward, at least to the Matapédia valley (a distance of 240 km), although significant facies changes occur. The lower two units (Forillon and Shiphead) become significantly more terrigenous, and almost exclusively so locally, while the upper siliceous limestones can still be recognized. A slaty facies (Fortin, Témiscouata or Seboomook facies), locally highly dolomitic and/or calcareous, is bounded to the south and to the north by the Upper Gaspé Limestones. The slaty facies is a central basin development, but this is far more problematical in the western half of Gaspé. The previous two-fold division of these limestones (Cap Bon Ami-Grande Greve Formations) is not realistic and has been abandoned.

The Upper Gaspé Limestones are most fossiliferous in the Forillon Peninsula but limited areas elsewhere are also fossiliferous. The uppermost part of the Forillon Formation is highly fossiliferous but the remainder is almost barren, and is identical to Percé Rock. The lower Shiphead is also fossiliferous, and similar to the underlying strata. Species of the brachiopods *Acrospirifer*, *Costispirifer*, *Dawsonelloides*, *Discomyorthis*, *Leptocoelia*, *Leptostrophia*, and *Pleiopleurina* are particularly abundant. The remaining Shiphead is less fossiliferous, but trilobites are more abundant (*Forillonaria*, *Synphoria*). The lower half of the Indian Cove Formation is poorly fossiliferous (infrequent trilobites include *Roncellia gaspensis*, *Odontochile townsendae*, and *Synphoria dolbeli*) while the upper half is highly fossiliferous. The beginning of the upper half (upper 72 m) is marked by abundant *Etymothyris gaspensis* which permits easy correlation elsewhere (Esopus of N.Y., etc.). Other fossils that are notable at this level are *Costellirostra peculiaris*, numerous other brachiopods, corals, and the trilobites *Phacops cristata* and *P. clarksoni*. The uppermost 14 m yield a less diverse fauna, notable, however, by the abundance of the brachiopods *Anoplia nucleata*, *C. peculiaris*, *Eodevonaria melonica*, *Strophodonta galatea* and the distinctive trilobite *Schoharia quebecensis*. The upper 72 m of the Indian Cove Formation is distinctly shallower water than the lower half. Only a small thickness of the overlying Gaspé Sandstones is marine (York River Formation) in northeastern Gaspé.

[Ami, Schuchert and Clarke. 1900. *In* Clarke, New York

State Mus. Mem. 3, p. 81; Lésperance. 1980. Québec Ministere Energie Ress. DPV-595 (see also Lésperance. 1975. Jour. Paleontol., p. 91); Logan. 1863. Geology of Canada, p. 391; Russell. 1976. Québec Minerales Richesses Naturelles DP-347 (also in Cumming. 1959. Geol. Surv. Canada, Mem. 304).]

PALEOENVIRONMENTS AND DEPOSITIONAL HISTORY OF THE WILLIAMSON-WILLOWVALE SHALES, SILURIAN, WESTERN NEW YORK

LIN, Bea-Yeh, and BRETT, Carlton E., Dept. of Geological Sciences, University of Rochester, Rochester, NY 14627

The Williamson Shale is a black to dark green, graptolite-bearing unit of the upper Clinton Group in western New York State. It grades eastward into gray fossiliferous shales and coquinoid limestones of the Willowvale Formation.

Progressive overstep of underlying units indicates that the basal onlap surface of the Williamson-Willowvale interval represents a major unconformity increasing in magnitude from east to west. The base of the Williamson consists of pyritic, quartzose and phosphatic granule-pebble lag conglomerate representing relict sediments reworked during a widespread (late Llandoverian C6) marine transgression; this basal bed appears to grade eastward into the Westmoreland oolitic hematite bed.

The marine faunas in the Williamson-Willowvale Shales are dominated by benthic brachiopods and pelagic graptolites. Four Associations are as follows: (A) Ichnofossil (*Chondrites*) Association, (B)*Monograptus-Retiolites* Association, (C)*Plectodonta-Atrypa* Association, (D)Bryozoan-*Palaeocyclus-Costistricklandia* Association. The spectrum of fossil preservation appears to reflect the increasing frequency of bottom disturbance by waves and currents in going from deeper basinal areas to a higher-energy shallow shelf setting. The fossil associations of the Williamson (A, B, C) probably belong to deeper water Benthic Assemblage (BA-5) but developed within storm wave base, about 50-80 m deep. The Willowvale associations (C, D) belong to shallower BA-5 to BA-4 (or possibly even to BA-3), and probably represent water about 10-50 m deep.

Subsurface data and paleocurrent analysis of graptolites (*Monograptus clintonensis*) indicate that the Williamson was deposited along the axis of a narrow NE-SW trending basin, probably closed at its northern end, and extending southward into Ohio where it grades into the Estill Shale.

Orientation of graptolites in western New York reveals a dominantly NE-SW trend approximately parallel to the basin axis with a minor longshore component.

Black, graptolitic facies of the Williamson are largely restricted to the base of this unit. The presence of graded, brachiopod-rich, coquinite limestones, and rippled, cross laminated sandstone beds within this facies indicate that this black shale facies was deposited in relatively shallow dysaerobic to marginally aerobic water within storm wave base.

Dark coloration of these shales and partial pyritization of monograptids suggest rapid burial of organic matter in anoxic muds. Intercalation of graptolitic black muds within thin, cross laminated quartz arenites further indicates that these dark bands were formed during episodic storm depositional events.

Association of abundant, aligned, broken graptolites with coarser clastics further suggests that the rhabdosomes were slightly transported and concentrated during periods of increased current activity. If *Monograptus* is assumed to have been pelagic, overturn or upwelling of anoxic water during storms may have resulted in mass mortality of these graptolites which then sank to be reworked by currents. Poorly fossiliferous green shales higher in the Williamson appear to reflect slow deposition in dysaerobic water and suggest a gradual deepening. Reappearance of brachiopod coquinite limestones (storm layers) near the top of the Williamson records a gradual shallowing, culminating in a previously unrecognized thin, quartz and phosphatic granule bed at the upper contact. This bed represents a brief but widespread regression, possibly correlated with the conglomeratic base of the Dawes Sandstone to the east.

AUTECOLOGY, BASED ON MODE OF PRESERVATION, OF SOME MIDDLE DEVONIAN BIVALVES

LINSLEY, David M., Dept. of Geological Sciences, SUNY University Center at Binghamton, Binghamton, NY 13901

Siltstones and shales of the Hamilton Group of New York contain a taxonomically diverse and well preserved assemblage of bivalves. The lower Hamilton Skaneateles Formation contains numerous 5 to 20m-thick, coarsening upward cycles which are interpreted as shallowing upward environments. The shales at the base of the cycles may have been near an anoxic, density-stratified boundary. The siltstone to very fine sandstone portion of the cycle has increasingly large bedforms (1-10 cm) that were deposited above storm wave base. In each depositional cycle, there is a distinct pattern of faunal replacement. Low taxonomic diversity in the shale grades upward into a high diversity assemblage in the coarser grained facies.

The relationship between rock type and mode of preservation is clear. High deposition rates with a minimum of wave or current activity on the substrate preserve bivalves in life position. Within the depositional cycle, optimum preservation is in the fine- to medium-grained siltstones. The shales, while preserving fine detail, had low rates of deposition. This allowed for continuous reworking of the upper centimeters of substrate and resulted in disassociated valves and shells that were moved from life position. Valves in shales are most often found disarticulated and disassociated with the commissures parallel to stratification. Silty shales through medium siltstones preserve bivalves in life position. Infaunal species were found with valves together and commissure perpendicular to the stratification, the normal life position for most modern infaunal bivalves. Surrounding sediment kept valves together, and an infaunal mode of life kept them below the sediment-water interface and isolated from bioturbation. Species interpreted as shallow infaunal or epifaunal are found with valves open but joined with commissures lying on stratification surfaces. Sandstones were extensively reworked by both marine and biogenic processes. Valves in sandstones are predominantly disassociated and preserve little information on life position.

Species interpreted as infaunal are found most often with valves together and commissure perpendicular to substrate. These include *Nuculoides corbuliformes*, *N. bellistriata*, *Modiella pygmaea*, *Paracyclas lirata*, *Tellinopsis subemarginata*, *Grammysia arcuata* and *G. alveata*. *Grammysia bisulcata*, a large (5-10 cm) bivalve, is found with the valves slightly open but with the plane of commissure perpendicular to stratification. *G. bisulcata* may have been semi-infaunal with the ligament working to slightly open the shell after death. Species with valves associated but spread apart are interpreted as semi-infaunal. These include *Orthonota parvula*, *Sphenotus solenoides*, *Goniophora hamiltonensis*, *Phthonia sectifrons*, and, possibly, *Cypricardella tenuistriatus*.

TRILOBITE BIOSTRATIGRAPHIC MODELS AND THE PALEOENVIRONMENT OF THE BURGESS SHALE (MIDDLE CAMBRIAN), YOHO NATIONAL PARK, BRITISH COLUMBIA

LUDVIGSEN, Rolf, Dept. of Geology, University of Toronto, Toronto, Ont. M5S 1A1

According to all recent investigations, the Burgess Shale (and its entombed fossil treasure) was deposited at the base of a 150-200 m high escarpment formed by a vertical reef wall of the Cathedral Formation against the basinal Stephen Formation.

This paleoenvironmental setting is a direct result of W.H. Fritz' (1971) biostratigraphic model which attempted to explain the distribution of trilobites in Middle Cambrian carbonates and shales of Yoho National Park. Fritz demonstrated that the contact between the *Glossopleura* Zone and the overlying *Bathyuriscus-Elrathina* Zone climbs from the lower part of the Stephen, up the reef wall, to the top beds of the Cathedral. He concluded that the zonal contact represents a time line, and, as such, it defines the escarpment as a Middle Cambrian bathymetric feature. Accordingly, deposition of the Stephen Shale postdates the Cathedral carbonates. Implicit in this biostratigraphic model is the belief that the distribution of the zonally-diagnostic genera in both carbonates and shales is controlled solely by temporal factors.

An alternative biostratigraphic model suggests that the distribution of trilobite genera in these strata is controlled primarily by environmental factors. Thus, the zones established on the basis of genera are, more properly, called biofacies: a low diversity "*Glossopleura* biofacies" restricted to carbonates of the lower Stephen (Boundary limestone) as well as in the Cathedral and a higher diversity "*Bathyuriscus-Elrathina* biofacies" restricted to shales and argillaceous limestones of the Stephen above the Boundary limestone. Transgression superposed "*Bathyuriscus-Elrathina* biofacies" over the "*Glossopleura* biofacies" at different Middle Cambrian times. According to this model, the Stephen shales are equivalent to the Cathedral carbonates and the "escarpment" becomes simply a line of facies change. The Burgess Shale is likely to have been deposited at the base of a gently sloping ramp.

CORRELATION OF UPPER ORDOVICIAN STRATA ON THE BASIS OF CONODONTS

McCRACKEN, Alexander D., and NOWLAN, Godfrey S., Geological Survey of Canada, 601 Booth Street, Ottawa, Ont. K1A 0E8

Fauna 13 is characterized by *Gamachignathus ensifer* McCracken *et al.* and *G. hastatus* McCracken *et al.* and has been used as an informal acme zone. Relative abundance values have been calculated to compare faunas of Anticosti Island, Québec, with those of other localities. The values are low in the Vauréal Formation, but there is a dramatic increase in the overlying Ellis Bay Formation (average about 32 percent) that is coincident with the base of Fauna 13.

The first occurrence of *Gamachignathus ensifer* in the Vauréal Formation is defined as a formal biohorizon. It marks the base of the *G.ensifer* Biozone that ranges from upper Richmondian through Gamachian. The *G. ensifer* Biohorizon is recognized in two faunas from clastic facies of the Road River Group in northern Yukon Territory. One of these faunas is 1 m below a *Diceratograptus* cf. *D. mirus* graptolite biohorizon and probably correlates with Anceps Bands C and D (lower *Paraorthograptus pacificus* graptolite Subzone) of Dob's Linn, Scotland.

The first appearance of *G. hastatus* and a subspecies of *Pseudobelodina*, and the last occurrence of *Plectodina*, as found in the Vauréal Formation, also may be useful biohorizons. *Amorphognathus* does not occur higher than the lower Gamachian and thus correlation with the *A. ordovicicus* Zone is uncertain. Both faunas from the Yukon contain *Amorphognathus*, *Plectodina* and very rare *G. ensifer*; these faunas are probably upper Richmondian rather than Gamachian.

The Fauna 13 interval and the Gamachian Stage may correspond to strata of the Anceps Band E and the *Climacograptus*? *extraordinarius* Band of Dob's Linn. The *G. ensifer* Biohorizon, and the bases of the *G. ensifer* Biozone and the Gamachian, are probably upper Rawtheyan.

The upper limit of the Gamachian, the Fauna 13 interval and the *G. ensifer* Biozone, is defined by the lower limit of "Silurian" conodonts. The lowest strata of the latter zone on Anticosti Island contain a mixed conodont fauna that includes taxa usually regarded as Silurian. The basal Silurian *Parakidograptus acuminatus* graptolite Biozone is not known in Anticosti strata but is likely higher than these "Silurian" conodonts.

Gamachignathus probably favoured cool-water environments, and immigrated to areas marginal to Laurentia in the latest Ordovician as a response to glacial cooling. It is unlikely that *Gamachignathus* and Fauna 13 will be found in cratonic areas.

LOWER CAMBRIAN MICKWITZIID BRACHIOPODS

MCMENAMIN, Mark A.S., Dept. of Geology and Geography, Mount Holyoke College, South Hadley, MA 01075

Mickwitziid brachiopods are a distinctive group of Cambrian phosphatic inarticulates that are characterized by abundant punctae. Mickwitziids first appear in the lowest Cambrian, and, before the end of the Early Cambrian, they attain sizes (over 3cm valve diameter) that are anomalously large for Early Cambrian brachiopods.

Mickwitziids have a three-layered shell wall architecture. Punctae perforate all three shell layers. A hollow apatitic tube runs along the axis of each puncta. The distal terminations of punctae are tiny pores in the outer wall layer; the proximal terminations form mound-like structures on the inner valve surface.

Punctae in modern brachiopods can provide protection from shell borers and predators by providing a channel for secretion of anti-fouling toxins. The punctae in mickwitziids probably protected these brachiopods from Early Cambrian predators and shell borers. This may explain why some mickwitziids were able to reach sizes that are large relative to other Early Cambrian brachiopods.

VENDIAN MACROBIOTA OF THE WERNECKE MOUNTAINS, YUKON, CANADA

NARBONNE, Guy M., Dept. of Geological Sciences, Queen's University, Kingston, Ont. K7L 3N6, and HOFMANN, Hans J., Dept. of Geology, University of Montreal, Montreal, Que. H3C 3J7

Ediacaran-type fossils occur in four unnamed units in the post-tillite, pre-Cambrian strata of the Windermere Supergroup, east-central Yukon Territory. The oldest fossiliferous strata, a siltstone unit deposited under deeper-water slope conditions, exhibits sporadic "medusoids" and probable coelenterate attachment discs. The middle clastic unit consists of interbedded shale and fine sandstone deposited on a shallow shelf. Its fossil assemblage is dominated by the problematic megafossil *Beltanelliformis* with fewer "medusoids" and carbonaceous metaphytes. The uppermost clastic unit also comprises a shallow shelf sandstone/shale sequence rich in *Beltanelliformis*; several genera of "medusoids", a pennate coelenterate, and three genera of simple trace fossils also are present. Overlying shallow shelf carbonates contain only simple trace fossils. A pronounced disconformity separates these strata from the overlying Vampire Formation, which contains arthropod trace fossils (e.g. *Cruziana*, *Rusophycus*) and small shelly fossils (e.g. *Anabarites*, *Protohertzina*) in its basal beds.

The Wernecke assemblage is similar to other occurrences of the Vendian/Ediacaran fauna but is most closely comparable with the Valdai assemblage of the Russian Platform. In addition, the overall sequence of fossils in the two areas is similar, implying that evolutionary stages within the type Vendian may be globally significant.

CONODONT COLOR ALTERATION DATA FROM THE ST. LAWRENCE PLATFORM AND APPALACHIAN OROGEN IN EASTERN CANADA

NOWLAN, Godfrey S., Geological Survey of Canada, 601 Booth Street, Ottawa, Ont. K1A 0E8, and BARNES, Christopher R., CERR, Dept. of Earth Sciences, Memorial University of Newfoundland, St. John's, Nfld. A1B 3X5

Color alteration indices (CAI) for conodonts from over 160 localities in eastern Canada have been assessed. These data have been plotted on five base maps for divisions of the Ordovician and Silurian. Summary maps have been prepared for each of the following areas: Quebec Basin, Anticosti Basin and Gaspésie. Isopleths have been drawn where possible and the resulting patterns are used to interpret the thermal history of each area. The patterns reflect episodes in the tectonic history and permit assessment of economic potential of each area. A high thermal anomaly in the southern Quebec Basin, previously interpreted to result from intrusions related to the passage of a Mesozoic hotspot, is more clearly defined. A high thermal anomaly in the northeastern part of the Anticosti Basin may also be related to the passage of a hotspot or possibly to tectonic loading associated with the Taconic and Acadian orogenies. Regional variation of CAI data in autochthonous strata suggests that the two main Taconic allochthons in Newfoundland were discrete. Within the allochthons, CAI values vary from 1 in frontal thrusts to 5 in the central ophiolite slices. Thermal anomalies in Gaspésie are related to buried, probably granitic, intrusions of tectonic origin.

Areas appropriate for further hydrocarbon exploration are identified: particularly eastern Gaspésie, northern Québec Basin, Anticosti Basin and the overthrust zone on the western margin of the Appalachian Orogen. It is proposed that conodont CAI data can be used to determine the temperature of ore-bearing fluids in Mississippi Valley-type base metal deposits and to identify buried intrusions that may host other types of ore deposits.

CORRELATION OF THE UPPER ORDOVICIAN AND LOWER SILURIAN STRATOTYPES OF BRITAIN AND PARASTRATOTYPES OF ANTICOSTI ISLAND, CANADA

PETRYK, Allen A., Ministere de l'Energie et des Ressources, Québec City, Que.

The final decision by the Commission on Stratigraphy of the International Union of Geological Sciences (IUGS) on the establishment of Ordovician-Silurian boundary stratotype and stratotypes for the subdivisions (stages) of the Llandovery Series has now been made. Preliminary decisions were taken by the Subcommission on Silurian Stratigraphy (SSS), as reported by C. Holland, the former Chairman of the SSS, at the 27th International Geological Congress held in Moscow in August, 1984. Graptolite-rich, deep-water, basinal shale facies have been chosen in which to establish these international correlation standards. The historical Dob's Linn section in Scotland was chosen over Anticosti Island (Québec) for the O-S boundary stratotype.

Over the past decade, concerted efforts were made by Canadian working groups to define these boundaries and stages in the dominantly shelly, shallow-water, platform carbonate facies of the Anticosti succession. The chronostratigraphic and lithostratigraphic uniqueness of the Anticosti sequence was recognized in 1857 by Billings and, in detail, in later studies by Schuchert and Twenhofel (1910) and Twenhofel (1928). The author has recently completed a lithostratigraphic calibration and analysis of the Anticosti sequence; this framework will assist in the elaboration of the biostratigraphic-chronostratigraphic succession of Anticosti Island as well as in coeval (parastratotype) successions elsewhere. Inferences about the ecostratigraphic, bathymetric and glacio-eustatic evolution of the Anticosti succession suggest that biostratigraphic successions based on graptolite, conodont, ostracode, trilobite, brachiopod, aulacerid stromatoporoid, and rugose coral taxa are closely, if not directly, correlative with the lithostratigraphic succession. Final arbitration on the precise location of the O-S boundary, however, is pending.

A chart will show the general limits and correlations between the British and Anticosti chronostratigraphic schemes. Moreover, a figure that denotes the lithostratigraphy, as well as, the inferred transgressive-regressive cycles of sedimentation and the geochronology of the Anticosti sequence is applied to the chronostratigraphic scheme.

CRUZIANA STRATIGRAPHY OF THE LOWER ORDOVICIAN BELL ISLAND AND WABANA GROUPS, CONCEPTION BAY, EASTERN NEWFOUNDLAND

PICKERILL, R.K.and FILLION, D., Dept. of Geology, University of New Brunswick, Frederickton, N.B. E3B 5A3

Unfossiliferous or poorly fossiliferous sedimentary sequences potentially can be dated and correlated by detailed examination of trace fossils. This approach has been widely applied to many Cambrian-Ordovician sequences in England, Wales, southwest Europe, and the Mediterranean region. The trilobite-produced ichnospecies of *Rusophycus* and *Cruziana* have been the most useful trace fossils in biostratigraphy. However, the ichnostratigraphic paradigm developed in Europe has not been successfully applied to any coeval succession in North America until the present.

The Lower Ordovician sequence (Bell Island and Wabana Groups) on Bell Island, Conception Bay, eastern Newfoundland, consists of shallow subtidal siliciclastics with a diverse, abundant, and well preserved trace fossil assemblage. Spectacularly preserved, trilobite-produced trace fossils, including *Cruziana* (furrowing traces), *Rusophycus* (resting traces), *Diplichnites* (walking tracks), *Dimorphichnus* (sideways grazing traces) and *Monomorphichnus* (swimming-grazing traces) are present in this assemblage. Detailed examination of the distribution of *Cruziana* species within the sequence has enabled a more accurate definition of the Tremadocian-Arenigian and lower-upper Tremadocian boundaries than previous paleontological studies have permitted. The former boundary is based on the final occurrence of *C. semiplicata*, which is an Upper Cambrian-Tremadocian species, and the latter is based on the initial occurrence of *C. furcifera* and *C. goldfussi*. These latter species have been reported previously from upper

Tremadocian and younger strata. It is suggested that the Tremadocian-Arenigian boundary be placed at the 1,200 m level and the lower-upper Tremadocian boundary at 1,020 m in the sequence.

TRILOBITE FAUNA OF THE UPPER BOBCAYGEON FORMATION (MIDDLE ORDOVICIAN, KIRKFIELDIAN), SOUTHERN ONTARIO

RUDKIN, David M., Dept. of Invertebrate Palaeontology, Royal Ontario Museum, Toronto, Ont. M5S 2C6, and BRETT, Kevin, 228 Livingston Road, Scarborough, Ont. M1E 1L7

Relatively new exposures of the middle and upper members of the Bobcaygeon Formation, located east of Lake Simcoe, southern Ontario, have yielded a moderately diverse assemblage (at least sixteen species) of well preserved trilobites. Taxa recovered so far are largely representative of Ludvigsen's (1978) Fauna F of Kirkfieldian age although several species formerly considered restricted to, or characteristic of, the succeeding Shermanian Fauna G (lower member, Verulam Formation) are now known to range down into the Bobcaygeon. These include *Cyphoproetus wilsonae*, *Dimeropyge gibbus* and *Hemiarges paulianius*. *Thaleops ovata* has not yet been confirmed in the new collections, but *Nanillaenus* sp. cf. *N. angusticollis* is abundant in some samples. A number of rare species, including "*Isoteloides*" *homalonotoides* and *Cybeloides plana*, previously known from indifferently preserved, unique or poorly located specimens, are now represented by more adequate material. At least one new species is present.

The trilobites occur, along with the diverse echinoderm faunas, for which the upper Bobcaygeon is renowned, in a sequence of thin- to thick-bedded limestones and thin shale interbeds with occasional hardground horizons. The sequence has been interpreted as representing an intershoal to deep shoal facies of the major Trenton transgressive event (Brett and Brookfield, 1984).

TRIASSIC CONODONTS FROM THE MAMONIA COMPLEX OF CYPRUS

RYLEY, Christopher C. and FAHRAEUS, Lars E., Dept. of Earth Sciences, Memorial University of Newfoundland, St. John's, Nfld. A1B 3X5

The Mamonia Complex, situated in the southwest of Cyprus, is an allochthonous assemblage composed of Triassic to Cretaceous sediments, Triassic mafics, and subordinate metamorphics which have been juxtaposed against the Troodos Complex (an ophiolite suite). The Complex has been subdivided into two groups: the Ayios Photios Group, a wholly sedimentary assemblage recording continental margin sedimentation, and the Dhiarizos Group, a primarily igneous assemblage recording continental margin volcanism and associated sedimentation.

The Ayios Photios Group has been further subdivided into the following formations: the Vlambouros Formation (Upper Triassic), representing a transition from shallow- to deep-water flysch sedimentation within a subsiding basin, the Marona Formation (Upper Triassic), characterized by pelagic limestones deposited along portions of the margin not receiving clastic sediments, and the Episkopi Formation (Jurassic to Lower Cretaceous), a sequence of primarily non-calcareous pelagic and hemipelagic sedimentary rocks. Similarly, the Dhiarizos Group has been further subdivided into the following formations: the Phasoula and Loutra tis Aphroditis Formations (Triassic), characterized by alkaline extrusive and intrusive rocks representing volcanism associated with the onset of major crustal extension, and the Petra Tou Romiou Formation, representing organic reef buildups associated with Loutra tis Aphroditis volcanism.

Conodonts have been recovered from the Vlambouros, Marona, and Petra Tou Romiou Formations and from the Kholetria Member of the Loutra tis Aphroditis Formation. The conodonts are indicative of Norian age (Late Triassic). A tentative list of species includes *Cornudina tortilis*, *Epigondolella abneptis*, *E. bidentata*, *E. postera*, *E. spatulata*, *Misikella hernsteini*, *M. koessenensis*, *M. posthernsteini*, *Neogondolella communisti*, *N. navicula halstattensis*, *N.* sp. cf. *navicula navicula*, *N. navicula steinbergensis*, and *Oncadella paucidentata*.

THE MIDDLE DEVONIAN, BRACHYMETOPID TRILOBITE *AUSTRALOSUTURA GEMMAEA* (HALL & CLARKE, 1888), CLOSE RELATIVES, DESCENDANTS, AND ANCESTORS

SCATTERDAY, James W., Dept. of Geological Sciences, SUNY College of Arts and Science at Geneseo, Geneseo, NY 14454

Newly collected specimens of the species originally established as *Phaethonides gemmaeus* have revealed features that show this species should be referred to *Australosutura* Campbell and Goldring, 1960 – a genus first recorded in Pennsylvanian rocks located, as its name implies, in the Southern Hemisphere. Although the species has been referred to a plethora of genera (initially, even cranidia and pygidia were placed in different genera!), its most recent previous assignment was to *Mystrocephala* Whittington, 1960. *Mystrocephala* and *Australosutura* do share many characteristics, and the features formerly used to distinguish between them – angle of divergence of the facial suture (gamma to beta) from the sagittal line, conspicuousness of the anterior lateral glabellar furrow, and width of the frontal area of the cephalon – have proven to be of little value for this purpose. On the other hand, the two genera are separable by the differences in their rostral plates (in *Mystrocephala*, the plate is trapezoidal and therefore similar to that of *Radnoria* Owens and Thomas, 1975; in *Australosutura*, it is crescentic like that of *Brachymetopus* McCoy, 1847) and by the far greater prominence of the tubercules or spines on the thorax and pygidium in *Australosutura*. Indeed, in all known species of *Australosutura*, the distal spines on the pleurae project outward to or beyond the tips of the thoracic segments or the margin of the pygidium.

Australosutura gemmaea ranges from the Onondaga Limestone (Eifelian) through the Hamilton Group and into the Tully Limestone (Givetian) in New York and is found in the Mahantango Formation in Pennsylvania. It is succeeded in the Mississippian of North America by forms for which no fewer than ten names have been proposed. Collections are inadequate to determine with assurance whether only one or several species should be recognized, but forms proclaimed as first records of *Australosutura* in North America seem most certainly to be representative of earlier established species. Unfortunately, those species were either originally or subsequently assigned to *Brachymetopus*, a genus whose species apparently did not reach North America until late in the Pennsylvanian.

Australosutura gemmaea and the Mississippian species of *Australosutura* differ in two conspicuous ways. In *A. gemmaea*, the distance between the preglabellar and anterior lateral furrows is about one-third the length of the glabella; in the Mississippian species, the anterior lateral furrow lies roughly midway between the preglabellar and occipital furrows. In *A. gemmaea*, there are eight pygidial ribs; in the Mississippian species, there are usually nine or ten.

A species, which has only seven pygidial ribs and which is possibly ancestral to *A. gemmaea*, is found in Lower Devonian strata in New York. Another representative of *Australosutura* that is presumed to be older than *A. gemmaea* occurs in Bolivia. Unfortunately, the precise age of the rocks in which the Bolivian specimens were found is not known, leaving uncertain whether the place of origin of *Australosutura* was in fact austral – or boreal.

RUGOSE CORALS FROM UPPER DEVONIAN FRASNIAN STRATA OF SOUTH-CENTRAL AND SOUTHWESTERN NEW YORK STATE

SORAUF, James E., Dept. of Geological Sciences, SUNY, University Center at Binghamton, Binghamton, NY 13901

Upper Devonian (Frasnian) rugose corals commonly are rare to non-existant in terrigenous clastic strata of the Catskill Delta in south-central and southwestern New York. Prior to 1977, mention of rugosans in these rocks was limited to description of one colony that was described as *Pachyphyllum vagabundum* by Ehlers in 1949 and five individuals assigned to *Macgeea ponderosa* and *Mictophyllum orientale* by Stumm in 1960. More recently, approximately 50 colonies of rugose corals were collected from the Wiscoy Sandstone of the Frasnian West Falls Group, west of Bath, New York. These were placed by Sorauf (1978) in *Pachyphyllum woodmani* and *P. crassicostatum*, species characteristic of Frasnian strata of Iowa. The Wiscoy Sandstone occurrence is within Chemung Magnafacies sandstones with large scale hummocks that contain the ichnogenera *Zoophycus* and *Skolithos*.

The Rhinestreet Formation of the West Falls Group also has yielded very large faunas of solitary and colonial rugosans in the Chemung Magnafacies near Waverly, New York. Three species are abundantly represented in the Rhinestreet assemblage: *Tabulophyllum orientale* (Stumm), *Macgeea ponderosa* Stumm, and *Disphyllum caespitosum* (Goldfuss). These corals, along with highly abundant fragments of the tabulate *Aulopora*, generally occur within storm deposits (coquinites) associated with sandstones containing hummocky cross-stratification. They reflect sedimentation on a sandy, storm-dominated shallow shelf region during this portion of the Frasnian. This is comparable to the later occurrence of colonial rugosans in the Wiscoy Sandstone.

The solitary species, *Tabulophyllum orientale* and *Macgeea ponderosa* are large forms of these genera, and, additionally, are seen to contain large amounts of biogenic stereome that thickens septa and tabulae and commonly completely fills the apical end of the corals. Apparently, this is an adaptation of the solitary rugosans for life on a somewhat unstable substrate and would have allowed them to maintain an upright position under conditions of wave and current action. In this characteristic, the two rugose species mimic modern ahermatypic corals, as typified by the modern genus *Caryphyllia*, which live with the apical skeleton buried in soft substrate.

PALEOECOLOGY OF THE LATE QUATERNARY HISCOCK SITE, GENESEE COUNTY, NEW YORK: AN INITIAL REPORT

STEADMAN, David W. and MILLER, Norton G., Biological Survey, New York State Museum, 3140 Cultural Education Center, Albany, NY 12230

The Hiscock Site is a rich accumulation of plant and animal fossils in a seasonally inundated peatland 1.5 km west of the Village of Byron, Genesee County, New York. The deposit, which covers about four acres, consists of two major stratigraphic units: an upper peat with abundant plant macrofossils (wood, cones, seeds, fruits) and an underlying deposit of clay with numerous small twigs and varying components of silt, sand, pebbles, and boulders.

Pollen analysis of sediment from one wall of a pit (H5SW) excavated near the west end of the deposit revealed the following sequence: 0-26.5 cm (post-settlement peat with abundant grass and ragweed pollen), 26.5-46.5 cm (peat, high percentages of beech, sugar maple, and elm pollen), 46.5-84 cm (peat, high percentages of pine and oak pollen), 84-177 cm (sandy, silty, gray clay to 143 cm and gray, clayey, silty sand with gravel and cobbles from 143 to 177 cm, high values [85%] of sedge, grass, and Compositae pollen, 10% spruce and 5% pine pollen). A bimodal hemlock pollen curve is absent. The radiocarbon age of wood at 30 cm (oak) and 45 cm (ash) is 250 ± 50 and 530 ± 50 yrs BP, respectively. Spruce wood at 90 cm and white pine wood at 89 cm (just below the organic to inorganic sediment transition) is 8610 ± 80 and 9340 ± 100 yrs BP, respectively. A composite sample of twigs from 145-155 cm is 10,930 ± 90 yrs BP, indicating a late Pleistocene age for much of the lower unit. Additional radiocarbon dates and correlations with pollen sequences in sediments from nearby lake basins will establish whether the deposition of peat has been continuous through the Holocene. The high nonarboreal to arboreal pollen ratio (ca. 9:1) in the lower (inorganic) unit is anomalous in the region but can be explained by heavy over-representation of pollen from plants that grew adjacent to or in the shallow basin. The high percentages of grass, sedge, and other herb pollen types in association with the low representation of spruce and the scarcity of pollen of all other trees except pine indicate that an open spruce woodland existed near the basin during the Pleistocene to Holocene transition. Cones of *Pinus banksiana* (jack pine) at 96, 99, and 118 cm from sediments bracketed by radiocarbon dates of 8610 ± 80 and 10,930 ± 90 yrs BP establish the local presence of this species when total pine pollen was less than 5% and pollen of *Pinus banksiana/P. resinosa* type was less than 1%.

Vertebrates recorded from the Holocene strata include the following: amphibians – Ranidae; reptiles – *Chelydra serpentina*, Emydidae; birds – *Anas* sp., *Buteo* cf. *lineatus*, *Accipiter cooperii*, *Meleagris gallopavo*, *Ectopistes migratorius*, *Strix varia*, *Colaptes auratus*, *Cyanocitta cristata*, *Corvus corax*, *Quiscalus quiscula*, *Icterus galbula*; mammals – *Blarina brevicauda*, *Lepus americanus*, *Sylvilagus* sp., *Marmota monax*, *Glaucomys* sp., *Castor canadensis*, *Peromyscus leucopus*, *Microtus pennsylvanicus*, *Ondatra zibethicus*, *Erithizon dorsatum*, *Odocoileus virginianus*, *Cervus canadensis*. The following are recorded from the lower unit: amphibians – Anura; reptiles – Emydidae; birds – *Podilymbus podiceps*, *Gymnogyps californianus*; mammals – *Mammut americanum*, *Cervus canadensis*, *Rangifer* sp. Only *Mammut americanum* is extinct, although *Gymnogyps californianus*, *Ectopistes migratorius*, *Corvus corax*, *Cervus canadensis*, and *Rangifer* sp.no longer occur in the vicinity of the site.

Certain vertebrates from both major units require standing fresh water as found in a fen or a marsh (Ranidae, *Chelydra serpentina*, Emydidae, *Anas* sp., *Podilymbus podiceps*, *Castor canadensis*, *Ondatra zibethicus*). The other vertebrates are characteristic of forests or mixtures of forest and open areas. The historically extinct *Ectopistes migratorius*, by far the most abundant bird in the peat unit, is an indicator of mature deciduous forests. The record of *Gymnogyps californianus* represents a range extension of approximately 1700 km, the nearest occurrence being from the late Pleistocene of Florida. *Icterus galbula* and *Podilymbus podiceps* are known from feathers only. This is the first time that entire feathers have been found in late Pleistocene or early Holocene deposits in eastern North America. Additional feathers are expected as more sediment samples are analyzed. Insects and aquatic snails, as yet unstudied, also have been recovered.

AN EVOLUTIONARY HISTORY OF THE GENUS *ECTENOCRINUS* FROM A STUDY OF THE BIOSTRATIGRAPHY OF ITS COLUMNAL FORMS

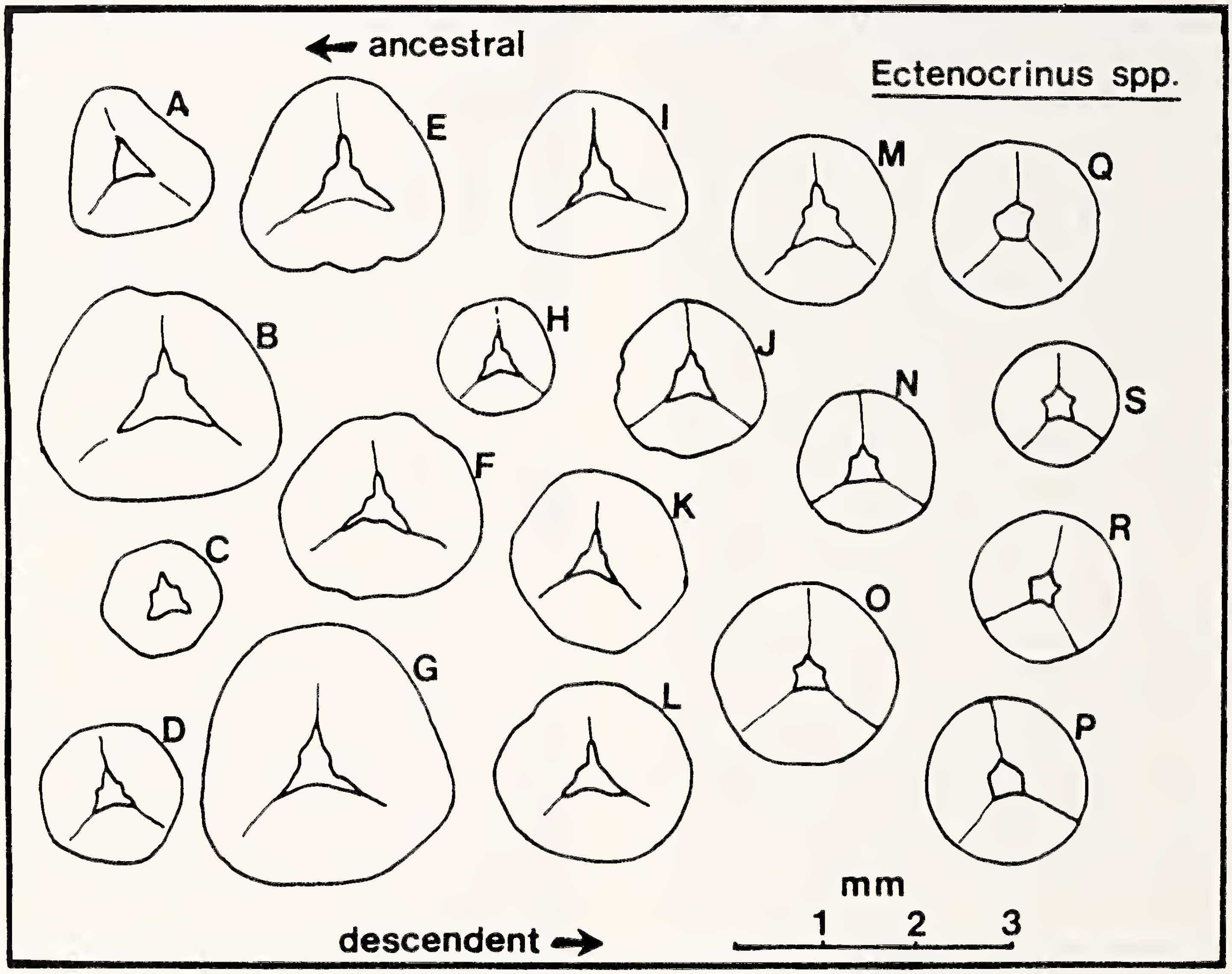
TITUS, Robert, Dept. of Geology, Hartwick College, Oneonta, NY 13820

A detailed survey of the sedimentary environments and facies patterns of the Trenton Group has been conducted over the past 15 years. The biostratigraphy of nearly 250 taxa has been determined and related to these facies patterns. As a result, the Trenton Group is now an excellent stratigraphic unit for the testing of various hypotheses concerning the fossil record of speciation events. This is the first of several studies that are underway.

The crinoid *Ectenocrinus* has unusual trimerus columnals which make them instantly recognizable (A-S). Such columnals first appear in the deep shelf facies of the lower Trenton Group (the Sugar River Limestone). In these strata, the columnals display roughly triangular shapes with nearly triangular lumens (A-J). A small minority of the early forms tend to have rounded shapes with five-sided lumens (N-P).

By the middle Trentonian, a definite cline developed. Deep water columnals display the ancestral triangular form while adjacent shallow water forms are rounded and have five-sided or pentagonal lumens (N-S). These round types came to be the beneficiaries of middle Trentonian facies changes. This was a time when the eastern bank margin steepened and narrowed. The deep shelf habitat shrank to the east and disappeared. Trapped in a failing ecosystem, the deep water members of the cline dwindled and disappeared before late Trentonian time. Only the well-rounded form with a pentagonal lumen survived (Q-S). This form, *Ectenocrinus simplex*, was a great success; its numbers increased and its range expanded throughout the remainder of Trentonian time.

The transition from the earlier triangular species to *E. simplex* is seamless. No boundary can be recognized. A simple and gradual shift of phenotype abundance characterized the event.



SPATIAL VARIABILITY IN TRILOBITE MASS EXTINCTION PATTERNS ACROSS AN UPPER CAMBRIAN STAGE BOUNDARY

WESTROP, Stephen R.[1] and LUDVIGSEN, Rolf, Dept. of Geology, University of Toronto, Toronto M5S 1A1

About 50% of North American trilobite families are eliminated during a "critical period" (*Eurekia apopsis* Subzone and *Missisquoia* Zone) which begins at the Sunwaptan Stage-Ibexian Series boundary. The extinctions are not distributed uniformly across the shelf – survivors tend to be families confined to, or most abundant in, shelf margin and upper slope biofacies prior to the stage boundary. In particular, families which extend into the upper slope *Bienvillia* Biofacies show significantly higher (G-test, $P < 0.0.05$) levels of survivorship (85%) than those which are confined to shelf biofacies (36%). However, families surviving and eliminated during the "critical period" do not differ significantly (Mann-Whitney U-test, $P > 0.1$) in the number of biofacies occupied prior to the extinctions, and a weak relationship between pandemicity and survivorship is not significant (G-test, $P > 0.1$).

The extinctions are related to a shelf-wide sequence of biofacies replacements. Comparison of species, genus and family extinctions at biofacies changes during, and more localized biofacies replacements prior to, the "critical period" indicate that the former differ only in the taxonomic level of extinctions–turnover at the family level is confined to the "critical period", possibly as a consequence of the greater geographic scale of biofacies change. The patterns of faunal change across the top of the Sunwaptan Stage are consistent with a biogeographic extinction model involving reduction in numbers of biofacies by cratonward migration of trilobites during a sea level rise. The significantly high survivorship of trilobite families which extend into upper slope biofacies is not surprising – upper slope biofacies actually expand onto the shelf during a sea level rise and can act as both a refuge and a pool of immigrants.

---

[1] Present address: Dept. of Earth Sciences, Memorial University of Newfoundland, St. John's, Nfld. A1B 3X5.

Position Papers of the North American Ordovician Chronostratigraphy Working Group

The first meeting of the North American Ordovician Chronostratigraphy Working Group was held in Albany during the 1986 Canadian Paleontology and Biostratigraphy Seminar/Sesquicentennial Celebration of the New York State Geological Survey. The following papers were submitted prior to and distributed to participants at this round-table discussion. These reports are individual or co-authored interim proposals for consideration by the Working Group. As "formal correspondences," these papers make recommendations on the methods and key fossil groups which are useful in establishing and correlating suggested subdivisions and boundaries of the Ordovician System in North America.

The "Position Papers" compose a relatively eclectic compendium dealing with problems in and solutions to correlation throughout the North American Ordovician. Several papers deal with proposed series- and stage-level boundaries in the System and suggest the fossil criteria and actual stratigraphic horizons at specified sections where these boundaries might be established. A number of other papers emphasize the paleoenvironmental and, consequently, geographic limits to biotic distribution in the Ordovician marine realm. The expected limitations to highly refined inter-regional correlation of series and stages arises because all chronostratigraphic units have a biostratigraphic basis; the base of a specified biotic zone also defines the base of a stage or series in the latter's type section or area. If species used to define that biotic zone are rare or absent or have a different stratigraphic distribution in a different region, the very basis for precise correlation or even the recognition of series and stages may be lacking. A further consideration would be that chronostratigraphy is not simply based on biostratigraphy but *is* biostratigraphy that is unfortunately laden with an overly strong faith that faunal succession carries an absolute and precise time signature between different paleoenvironmental regimes. Despite these concerns about the concept of "chronostratigraphy," it is hoped that the Working Group's activities will encourage and improve resolution in biostratigraphic work on the North American Ordovician. Improved relative time control is the basis for furthering an understanding of geological history in this interval and has direct application to economic utilization of resources in Ordovician rocks. The Working Group's meeting in Albany is very appropriate because many concepts of Ordovician correlation were based on this System in New York State.

The following individuals provided speedy and helpful review of the Position Papers: C.R. Barnes, A.J. Boucot, R.A. Cooper, M.J. Copeland, E. Landing, A. Lenz, R. Ludvigsen, J.E. Repetski, L.V. Rickard, S.R. Westrop, S.H. Williams.

Conodont Biostratigraphy of Some Middle Ordovician Stratotypes in the Southern and Central Appalachians

Stig M. Bergström[1], John B. Carnes[2], Jack C. Hall[3], Wolfgang Kurapkat[4] and Brian E. O'Neil[5]

[1] Department of Geology and Mineralogy, The Ohio State University
[2] 8215 Mobud Drive, Houston, Texas
[3] Department of Earth Sciences, University of North Carolina at Wilmington
[4] 10877 Fancher Road, Westerville, Ohio
[5] 7600 Kirby Drive, Houston, Texas

ABSTRACT

Numerous samples collected systematically through the reference sections of Cooper's (1956) Marmorian, Ashbyan, Porterfieldian, and Wildernessian stages, and Kay's (1947) Bolarian Series have produced large collections of conodonts. The presence of biostratigraphically diagnostic species permits assessment, with a variable degree of precision, of the biostratigraphic scope of each of these units. The type Marmorian is within the *Pygodus serra* Zone, or within that zone and the succeeding *Pygodus anserinus* Zone (Llandeilian and slightly older), depending on the choice of definition of the stage; the type Ashbyan is coeval with part of the *Baltoniodus gerdae* Subzone (lower Caradocian); the type Wildernessian, although containing few biostratigraphically significant conodonts, may range from the *E. quadridactylus* Zone to the *Belodina compressa* Zone, or possibly, to the *Phragmodus undatus* Zone (lower Caradocian); and the entire Bolarian probably is of *B. gerdae* Subzone age. It is concluded that the Marmorian is older than the Ashbyan and the Porterfieldian, which overlap almost

completely; the Wildernessian may overlap the uppermost Porterfieldian but this is not certain; and the Bolarian is coeval with a large part of the Ashbyan and Porterfieldian as well as with the Wildernessian. The conodont data are in good agreement with data from chitinozoans and graptolites. The reported conflict between conodont data and some of the brachiopod data is, in most cases, resolved when one considers the precise age of the local strata, various ecological and biogeographical factors, and uses species rather than genera for correlation.

INTRODUCTION

Ordovician rocks are widely distributed and excellently exposed in numerous sections in the Southern and Central Appalachians, but their detailed biostratigraphy still remains very incompletely known. Among the stratigraphically useful megafossils, only the Middle Ordovician brachiopods (Cooper, 1956), trilobites (Cooper, 1953; Whittington and Evitt, 1953, etc.), and graptolites (Finney, 1977, 1984, 1985) have been studied in some detail, but much remains to be learned about both the vertical and horizontal distribution of species of all of these groups. In the case of the microfossils, extensive work has been carried out on Middle Ordovician conodonts (Bergström, 1971, 1973, 1983; Carnes, 1975; Bergström and Carnes, 1976; Schmidt, 1982; O'Neil, 1985; Kurapkat, 1986; Hall, 1986), and more limited studies have been devoted to these fossils from the Lower and Upper Ordovician. Recently, Middle Ordovician chitinozoans from the Southern Appalachians were described by Grahn and Bergström (1985). The biostratigraphy of other groups remains essentially unknown.

The Middle Ordovician in the Southern and Central Appalachians is of particular interest because it includes the reference sections of several stages (Cooper, 1956) and one series (Kay, 1947). Although Cooper's (1956) stages have been particularly widely used in North America, their faunal basis has never been satisfactorily documented, not even in the reference sections.

As a part of the current efforts to establish a standard stadial classification for the North American Middle Ordovician, it is important to reassess previously recognized units in terms of the faunal succession, biostratigraphic scope, ease of recognition, and regional usefulness. This is particularly appropriate in view of the fact that the Middle Ordovican stadial nomenclature already contains a considerable number of terms, some of which have been redefined more than once. Adding new terms may increase the terminological confusion.

The purpose of the present paper is to review published and unpublished biostratigraphic information bearing on the reference sections of Cooper's (1956) Marmorian, Ashbyan, Porterfieldian, and Wildernessian stages as well as Kay's (1947) Bolarian Series. Because far more detailed data are available from conodonts than from any other fossil group, we will stress the conodont biostratigraphy, but we will pay due attention to evidence provided by other groups. As zonal schemes are available only for conodonts (Bergström, 1971, 1983; Sweet, 1984) and graptolites (Finney, 1977, 1985, 1986), and the latter group is not represented in most of the sections dealt with here, we will use the conodont zonal schemes as a general biostratigraphic framework of reference. The geographic locations of the section discussed are illustrated in Figure 1.

THE MARMORIAN STAGE

Definition

The Marmorian Stage was proposed (as the Marmor Stage) by Cooper (1956, p. 8), who indicated that the reference section is "along the railroad to the east of Marmor and extends from the Concord (T.V.A. 138-SW Quadrangle) to the adjacent Louisville (T.V.A. 138-SE Quadrangle)" and that "this stage includes the Chazy Group and its correlatives." There are three problems with this original definition.

Firstly, it is clear from Cooper (1956, Chart 1) that he considered the base of this stage to be distinctly older than the base of the Lenoir Limestone at the reference section near Friendsville, Blount County, Tennessee, but correlated it exactly with the base of the Day Point Formation of the Chazy Group in the Champlain Valley, New York. Accordingly, a strong case can be made that the stratotype of the base of the Marmorian should be in the Chazy area and not in eastern Tennessee. Secondly, Cooper's geographic reference is not sufficient to identify the precise location of the Marmorian reference section near Friendsville because there are two railroads (one removed since 1956) near Marmor and along both are intermittent exposures of the Lenoir Limestone. Bergström (1971, p. 124-125; 1973, p. 271) picked the long section along the Marmor road and the northern of these railroads (his Marble Hollow section; section C of Moehl, 1965) about 2 km northeast of Friendsville as the Marmorian reference section. At the southern railroad section, 1.3 km northeast of Friendsville, there is a similar sequence (section B of Moehl, 1965), which is, at least partly, less well exposed but which also has been collected for conodonts (Bergström, unpublished). None of these sections is very suitable as a stratotype for the lower half of the Marmorian, and a better section through that interval is at Friends Church in Friendsville (Bergström, 1973). A composite of the Marmor road and the latter sections has been pieced together as a general reference section for illustrating the conodont succession (Figure 2). A graphic correlation of that section was presented by Sweet (1984, fig. 11). Thirdly, the statement in the definition that the Marmorian "includes the Chazy Group and its correlatives" creates a problem if, as appears to be the case, the top of the Marmorian interval at Friendsville is not coeval with the top of the Chazy Group (the top of the Valcour Formation) in New York. In other words, should the top of the Marmorian be defined in terms of the Tennessee or the New York sequence?

Conodont Succession

The Marmorian strata at Friendsville, with a total thickness of about 80 m, contain moderately abundant, well preserved, and taxonomically varied conodonts. Neither the top, nor the base of the Marmorian interval at Friendsville is well controlled by zonal species, and the base of the Lenoir rests with prominent unconformity on Early Ordovician rocks. The top of the Marmorian is clearly within the upper half of the *Pygodus serra* Zone (Bergström, 1971, 1973; Jaanusson and Bergström, 1980, fig.7), but its exact position in terms of North Atlantic conodont subzones is uncertain although a form transitional between the subzonal indices *Eoplacognathus foliaceus* and *E. reclinatus* have been found 20-25 m below the top of the Marmorian (Bergström, 1973: Harris and others, 1979). As shown in Figure 2, the rest of the fauna includes *Cahabagnathus friendsvillensis*, *Phragmodus flexuosus* (with "cyrtoniodontiform" M element also in the basal Lenoir), *Ansella* spp., *Protopanderodus varicostatus* and *Periodon aculeatus* along with *Leptochirognathus* sp. and *Belodina monitorensis* and a few other species. If the top of the Valcour of New York is taken as the top of the Marmorian, then the stage will extend higher stratigraphically, namely to about the top of the *Pygodus anserinus* Zone (Sweet and Bergström, 1976).

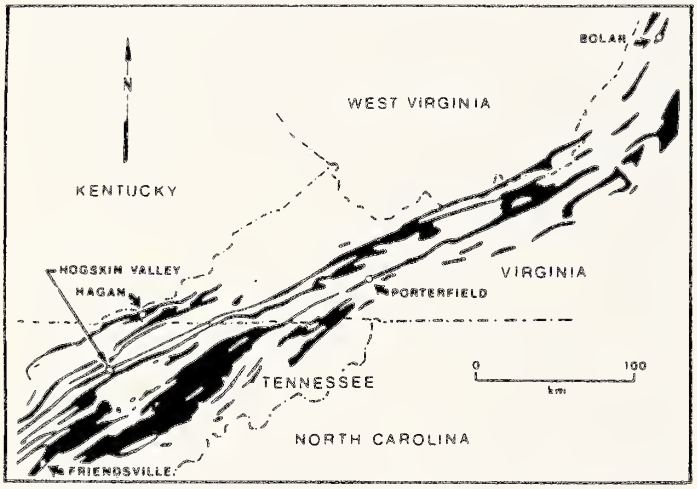


Figure 1 **Sketch-map showing the locations of Middle Ordovician stratotypes in the areas of Ordovician exposures (black) in the Southern and Central Appalachians.**

In the absence of index species, the exact age of the base of the Lenoir at Friendsville is uncertain, although it is likely to be within the *Pygodus serra* Zone (Jaanusson and Bergström, 1980, fig. 7). However, if the base of the Marmorian is defined as the base of the Day Point of New York, as implied by Cooper (1956), then the age of the latter level is more critical when assessing the scope of the Marmorian. Unfortunately, the base of the Day Point also is not well controlled in terms of conodont zones, but the data at hand (cf. Raring, 1972; Harris and others, 1979, fig. 16) suggest that it is closely similar in age to the base of the Lenoir at Friendsville; this is also suggested by graphic correlation (Sweet, 1984).

Chitinozoans

The vertical ranges of 12 species of chitinozoans in the Marble Hollow section were recorded by Grahn and Bergström (1985). The fauna in the lower 30-40 m of the unit includes only four species, three of which are stratigraphically long-ranging. The upper 40 m of the Marmorian interval has yielded specimens of 10 species, including *Conochitina clavaherculi*, which is best known from the Llanvirnian and early Llandeilian of Baltoscandia. As noted by Grahn and Bergström (1985), the biostratigraphic evidence provided by the chitinozoans is in good agreement with that of the conodonts.

Other Fossils

Brachiopods and other shelly fossils are moderately common in the Marmorian rocks at Friendsville but there are no graptolites. Cooper (1976, p. 175, 176) stressed the uniquely provincial aspect of the Marmorian *Mimella-Valcourea* suite of brachiopods but noted that "not one brachiopod genus is restricted to or diagnostic of the Marmor." Cooper (1956) provided no range data, but Moehl (1965) subdivided the Marmorian at Friendsville into three faunal zones and listed the shelly fossils in each. Only eight species of brachiopods were specifically identified, all from the middle of his three zones. Moehl (1965) also listed some trilobites.

Biostratigraphic Scope of the Marmorian

Based mainly on conodonts, with due consideration of the distribution of other fossils, especially chitinozoans, the Marmorian at Friendsville is interpreted to correspond to an interval in the *Pygodus serra* conodont zone, and to be coeval with the upper *Didymograptus murchisoni* and lower *Glyptograptus teretiusculus* graptolite zones. In terms of the British series, this interval corresponds to the upper Llanvirnian and slightly younger strata.

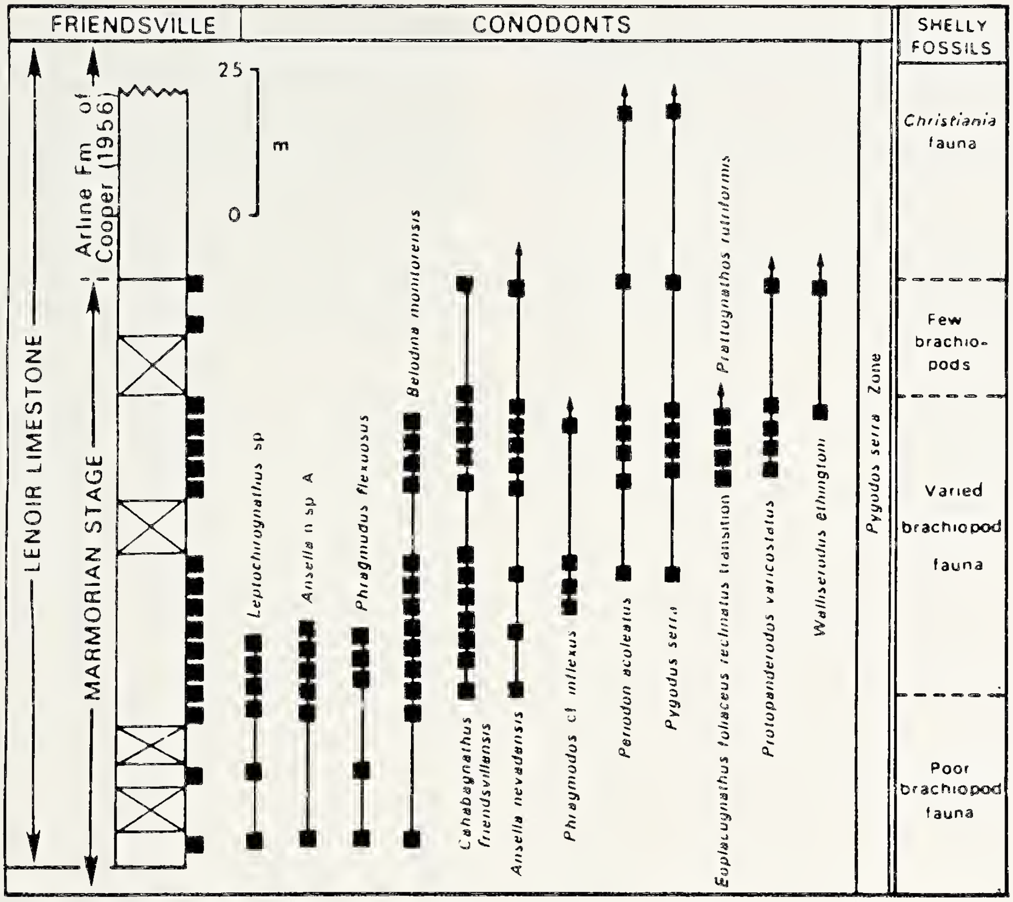


Figure 2 Ranges of selected conodont species through the Marmorian Stage reference section at Friendsville, Tennessee. Illustrated section is a composite of the Friends Church and Marble Hollow sections (Bergström, 1973). Some long-ranging coniform forms (*Drepanoistodus, Panderodus, Coelocerdontus)* and a few questionable compound taxa are omitted. Identifications based on Bergström (1973) but updated. Note that if the top of the Marmorian is defined as corresponding to the top of the Valcour Formation in New York, then the stage will extend higher (to near the top of the *Pygodus anserinus* Zone; cf. Figure 6).

THE ASHBYAN STAGE

Definition

The Ashbyan Stage, as originally defined (Cooper, 1956, p. 8), included the Elway and Lincolnshire (Edison and Hogskin) formations as developed in Hogskin Valley, Grainger County, Tennessee. Faunally, the stage was characterized as containing "many Chazy elements but it also contains brachiopods such as the coarse-ribbed dinorthids, which are unknown in the Valcour or any other part of the Chazy group. It is believed that the rocks deposited in the Ashby stage are younger than those of the Marmor (Chazy) group." Cooper (1976, p. 177) listed 12 brachiopod genera from the Ashbyan and regarded the presence of representatives of *Dinorthis* and *Sowerbyites* as especially characteristic of the unit. He also noted that most of the Marmorian genera are present in the Ashbyan and pointed out the important fact that the Ashbyan brachiopod assemblages are not known to follow the Marmorian ones in the eastern thrust belts.

Cooper (1956) gave no type section but the stadial name "is taken from a road intersection on Hogskin Creek, in the northeast quarter of the center subquadrangle of the Maynardville (30') Quadrangle, Tenn." The collecting localities in the Hogskin Valley listed by Cooper (1956), including those near the road intersection, are unsuitable as a stadial stratotype. The best section in Hogskin Valley is 5.2 km to the northeast and directly along strike of the road intersection, and we consider it to be the Ashbyan reference section. This is particularly appropriate because some of Cooper's brachiopod localities are in its immediate vicinity, and the Ashbyan units can be traced on the hillsides of the valley with virtually no significant interruption.

This section, which was described in detail by Carnes (1975), is known as the Lay School section. It begins on the Lay Farm on the southeast slope of Hinds Ridge and extends across Hogskin Creek to the road intersection just southeast of Lay School (2.7 km northeast of the Union County-Grainger County line and 0.3 km northeast of Mt. Eager Church) (SW 1/4 east-central rectangle, Powder Springs Quadrangle, Tenn. Div. Geol. Map GM 154-SW, Findlayson and others, 1965).

Conodont Succession

The Lay School section conodonts were studied in detail by Carnes (1975) and Figure 3 is based on his data. Of particular biostratigraphic importance for the definition of the base of the Ashbyan is the occurrence of forms

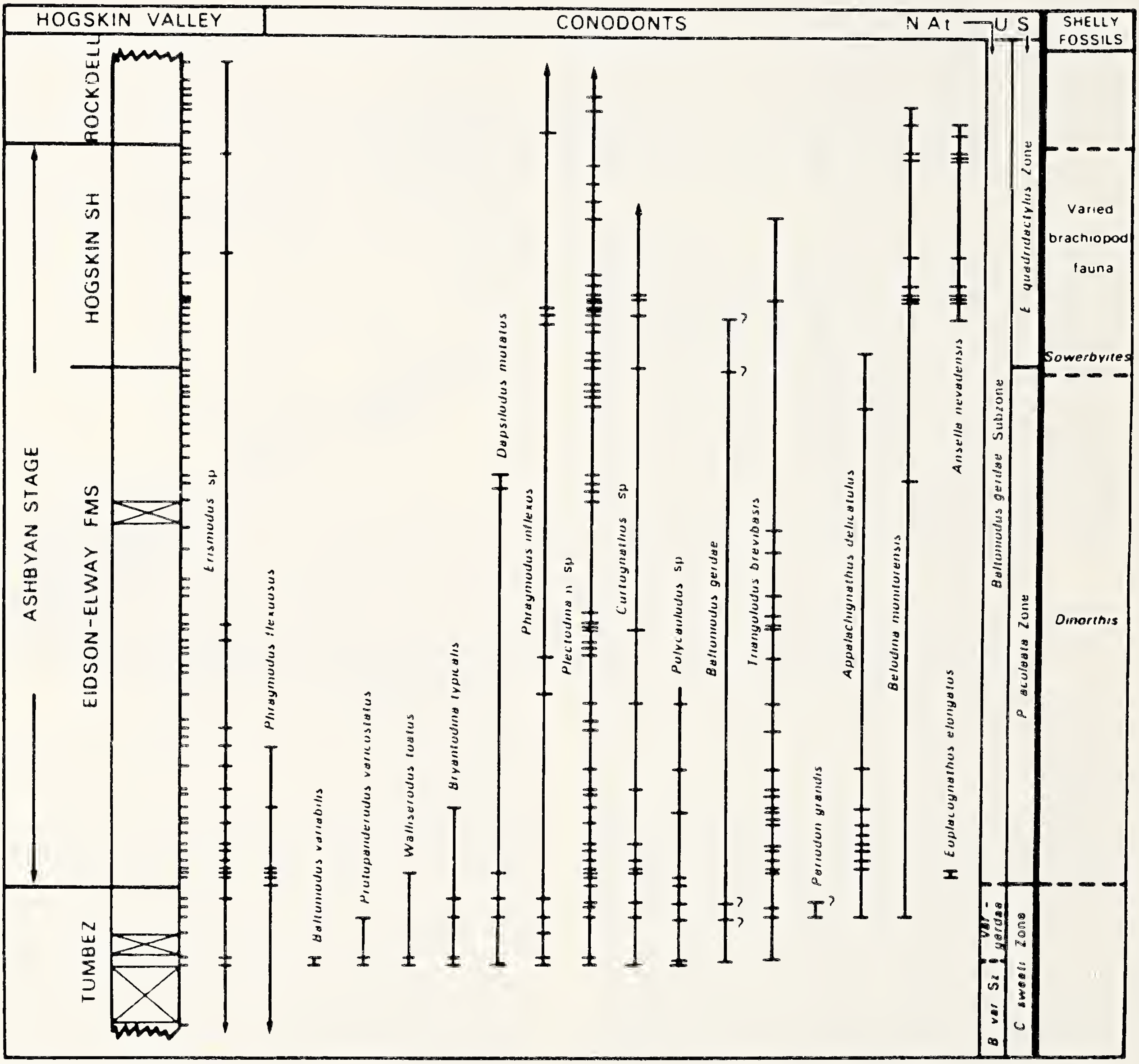


Figure 3 Ranges of selected conodont species through the Ashbyan Stage reference section at Lay School, Hogskin Valley. Based on identifications by Carnes (1975). A few long-ranging coniform forms (*Drepanoistodus, Panderodus, "Acodus"*) and a couple of questionable compound taxa are omitted. Note that the occurrences of *Baltoniodus gerdae* below the Ashbyan intervals represent the "early" form of Carnes (1975). N. Atl. denotes North Atlantic zonal units (Bergström, 1971, 1983); U.S. denotes the North Atlantic zonal units proposed by Sweet (1984).

transitional between the subzonal indices *Baltoniodus variabilis* and *B. gerdae* just below the base of the stage and specimens of *Eoplacognathus elongatus* in the lowermost 4-6 m of the stadial interval. The stage has a total thickness of about 240 m at Lay School. As indicated by Carnes (1975), the base of the Ashbyan in its type area may, for all practical purposes, be taken as the level of the base of the *B. gerdae* Subzone in the North Atlantic conodont zone succession. This level, in the Lay School section, also has been proposed to be the base of the Mohawkian Series (Bergström *in* Ross and others, 1982, p. 12; also cf. Sweet, this volume).

Most of the 20-25 species composing the Ashbyan conodont fauna are of limited biostratigraphic significance. The fauna is strongly dominated by Midcontinent and cosmopolitan taxa. Hyaline forms, such as species of *Erismodus*, *Curtognathus*, and *Polycaulodus*, range through the entire interval and become dominant 50-70 m above its top. It should also be noted that specimens of *Phragmodus inflexus* appear below the stadial base and range up to at least 70 m above its top; representatives of *P. flexuosus* are present in the lower 50 m of the unit; and specimens of *Plectodina aculeata* appear 50-70 m above the Ashbyan interval. Carnes (1975) interpreted the Ashbyan as being entirely within the *Baltoniodus gerdae* Subzone and corresponding to a major part of the interval of Midcontinent Fauna 7 of Sweet and others (1971). Sweet's (1984) graphic correlation of the Lay School section in its revised version (Sweet and Bergström, 1986; Sweet, this volume) has the base of the Ashbyan essentially coeval with the base of the *P. aculeata* Zone and the top corresponding to a level about one-third up into the *E. quadridactylus* Zone.

Shelly Fossils

In his monograph, Cooper (1956) records brachiopods from at least five localities in Hogskin Valley, none of them identical with the Lay School section. More than 20 species are listed from the Hogskin Shale, and a few from the Eidson and Elway formations, but their ranges through the Ashbyan remain unknown.

Other Fossils

No graptolites have been reported from the Ashbyan strata in Hogskin Valley, but Grahn and Bergström (1985, p. 102) recorded two long-ranging chitinozoan species from the Lay School section.

Biostratigraphic Scope of the Ashbyan

Based on brachiopod data, Cooper (1956, 1976) interpreted the Ashbyan to be younger than the Marmorian but older than the Porterfieldian. This opinion was challenged by Bergström (1971, p. 125) who, on the basis of conodont data from sections in Virginia, suggested that some rocks identified as Ashbyan by Cooper (1956) were coeval with strata of Porterfieldian age in terms of its reference section at Porterfield Quarry. He interpreted the Ashbyan brachiopods as a provincial fauna characteristic of the western thrust belts in the Southern and Central Appalachians that was coeval with the *Christiania* fauna in the eastern thrust belts. Subsequent study of the Hogskin Valley sections has strongly supported this interpretation (Bergström, 1973; Carnes, 1975). In a regional study of Middle Ordovician biofacies, Jaanusson and Bergström (1980) referred the Ashbyan faunas to their Tazewell Confacies Belt and noted their affinities to Midcontinent faunas. The fact that Ashbyan brachiopod faunas locally are present beneath strata having the *Christiania* fauna (Cooper, 1956, 1976) provides no firm evidence that the former are of pre-Porterfieldian age. As indicated by Bergstrom (1971), at the latter localities the base of the *Christiania*-bearing interval corresponds to a level well above the base of the Porterfieldian as it is developed in the Porterfield Quarry. However, it seems clear, for instance in Virginia (Bergström, 1971), that some strata with key Ashbyan brachiopods are slightly older than both the base of the type Porterfieldian and the base of the Ashbyan in Hogskin Valley. Regionally, both the base and the top of this unit, as defined on brachiopods, are markedly diachronous.

THE PORTERFIELDIAN STAGE

Definition

The Porterfieldian Stage is named for the Porterfield Quarry, a well-known fossil locality located on the south side of County Road 610 about 5.4 km west of State Route 16 and about 8 km east of Saltville, Smyth County, Virginia (Maccrady [T.V.A. 218-NW] Quadrangle). According to Cooper (1956, p.8) it is "characterized by the prolific and exotic fauna that floods into the Appalachians and blots out and absorbs the Lincolnshire fauna." This exotic fauna, the *Palaeostrophomena-Bimuria-Christiania* suite of Cooper (1976) that has European affinities, replaces the strictly North American Marmorian fauna. The Porterfield Quarry is obviously the logical reference section for the Porterfieldian Stage but rocks of the upper half of this stage (most of the Rich Valley and the entire Chatham Hill formations) are not exposed in the quarry and its vicinity. However, this part of the succession is relatively well exposed along State Route 16 about 0.8 km south of County Road 610 on the northwest face of Walker Mountain. These exposures are directly along strike to the north of the Porterfield Quarry, and we have used them for our studies of the conodonts of the upper Porterfieldian. Cooper (1956) also listed brachiopods from these outcrops.

Conodont Succession

The Porterfieldian conodont succession in the stage type area has been studied in some detail (Bergström, 1971; Markello and others, 1979; Kurapkat, 1986), and the conodont biostratigraphy of the lower part of the stadial succession, in particular, is now well known (Figure 4). The lowermost part of the Middle Ordovician succession, which consists of calcilutitic, very shallow-water rocks, has produced few conodonts. In our view, these strata represent the intitial deposits of the Middle Ordovician transgression, and we see no reason to postulate the existence of an unconformity at the top of this unit (Cooper, 1956) or within it (Ross and others, 1982, chart column 76). The conodont fauna of the overlying impure limestone ("Arline formation" of Cooper, 1956) is taxonomically varied and diagnostic biostratigraphically. The presence of specimens of *Cahabagnathus sweeti* and *Baltoniodus variabilis* indicates the *Amorphognathus inaequalis* Subzone of the *Pygodus anserinus* Zone (Bergström, 1971; Kurapkat, 1986). As indicated by Kurapkat (1986), the presence of *Cahabagnathus carnesi* in association with *C. sweeti* in the

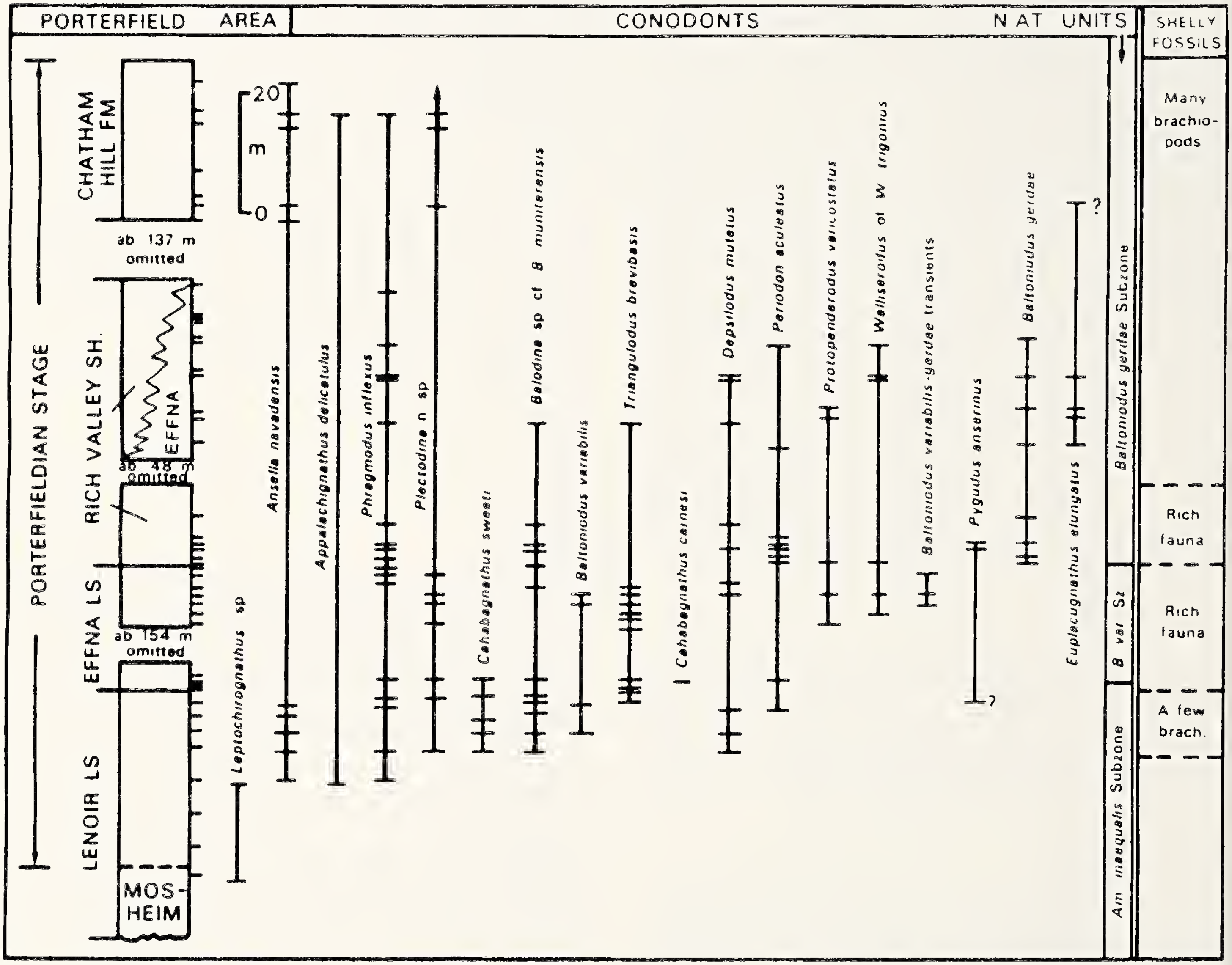


Figure 4 **Ranges of selected conodont species through the Porterfieldian Stage reference sections at Porterfield Quarry (Lenoir, Effna and lower Rich Valley formations) and on Walker Mountain (upper Rich Valley and Chapman Ridge formations), Virginia. Note that three substantial intervals are unavailable for systematic collecting. Some long-ranging coniform forms (*Drepanoistodus, Panderodus, "Oistodus"*,** Pseudooneotodus**) and a few questionable compound taxa are omitted. Based on identifications by Kurapkat (1986). Occurrences of shelly fossils after Cooper (1956). Note the occurrence of several important North Atlantic zonal indices in the uppermost Lenoir-lower Rich Valley interval.**

lowermost part of the overlying Effna Formation suggests a level close to the base of the *Amorphognathus tvaerensis* Zone (cf. Bergström, 1983). Most of the Effna, which represents a prominent build-up that is now largely quarried away, has not been collected in detail because of lack of exposure on the quarry floor. However, a series of samples from the uppermost part of the unit in the main quarry (Kurapkat, 1986) has produced interesting conodonts, including some displaying the transition from *B. variabilis* into *B. gerdae*. Typical specimens of the latter form appear near the Rich Valley-Effna contact and mark the base of the *B. gerdae* Subzone (Bergström, 1971; Kurapkat, 1986). As noted above, this subzonal boundary also is taken to be the level of the base of the Ashbyan Stage in Hogskin Valley. Higher strata in the Rich Valley Shale, as well as coeval strata in the upper part of the Effna buildup, contain representatives of *B. gerdae* and *Eoplacognathus elongatus* in association with *Phragmodus inflexus* and indicate the *B. gerdae* Subzone.

The Chatham Hill Formation along State Route 16 has yielded a biostratigraphically less diagnostic conodont fauna that is tentatively interpreted to represent the *B. gerdae* Subzone.

Shelly Fossils

The Porterfieldian units in the Porterfield Quarry and nearby areas have produced rich brachiopod faunas (Cooper, 1956, p. 42, 53, 60-61, 86) that include many rare species, but their ranges within the stage are not known except as lists of species from each formation.

Other Fossils

Graptolites have been reported from the lowermost part of the Rich Valley Shale (Decker, 1952), and a few poorly preserved specimens have been seen by Bergström (unpubl. data). They seem to represent the *N. gracilis* Zone, but study of Decker's (1952) specimens is necessary to confirm the graptolite dating.

Biostratigraphic Scope of the Porterfieldian

Based on conodonts, the type Porterfieldian ranges from the *Amorphognathus inaequalis* Subzone to, in all probability, a high level in the *Baltoniodus gerdae* Subzone. The age of the top of the stage in terms of conodont units remains uncertain, but it is of interest to note that we know of no section in the Southern and Central Appalachians in which rocks dated as Porterfieldian by Cooper (1956) are younger than the *B. gerdae* Subzone. In terms of graptolite zones, the type Porterfieldian ranges from about the middle of the *Nemagraptus gracilis* Zone to the lower part of the *Diplograptus multidens* Zone based on the conodont evidence (Bergström, 1971).

The Porterfieldian is clearly younger than the Marmorian, as represented by the top of the Marmorian interval at Friendsville, and there is little, if any, overlap with the Chazyan of New York. As indicated above, conodont evidence also suggests that the base of the type Ashbyan is markedly younger than the base of the type Porterfieldian.

THE WILDERNESSIAN STAGE

Definition

In his original definition of the Wildernessian (Wilderness) Stage, Cooper (1956, p. 8-9) indicated that it "includes the old Black River plus the Rockland and their equivalents. The fauna is especially characterized by abundance of *Opikina*, *Strophomena*, *Pionodema*, and *Doleroides*." He gave no specific reference section but noted that rocks of this age are well exposed for several miles east of Cumberland Gap and "revealed in their entirety along the railroad at the switch near Hagan, Rose Hill (T.V.A. 161-NE) Quadrangle," in the southwesternmost corner of Virginia. Because this is the best exposed and most extensive section in the Wildernessian type area, it is justified to consider it as the stadial reference section.

There are two problems associated with the establishment of this unit. Firstly, the scope of the stage is given differently on the left and right sides of Cooper's (1956) chart; the right side evidently being the correct one. Secondly, in the Hagan column on the same chart, the base of the stage is placed in the middle of the Hurricane Bridge Limestone and the top near the top of the Hardy Creek Limestone. Both of these units are fine-grained limestones that are very poorly fossiliferous as indicated by the fact that Cooper (1956, p. 69) listed only three brachiopods, none identified to species from the former unit, and from the latter unit two brachiopods, identified to species, one of which is said to be typical of "middle Trenton." Hence, the biostratigraphic basis of the Wildernessian is very weak in the type area, and the stadial boundaries are currently not defined, and probably can not be defined in terms of the megafossil succession.

Conodont Succession

Samples from the Wildernessian interval at Hagan (Hall, 1986) and elsewhere in the Jonesville district (Bergström, unpubl. data) have not produced a highly biostratigraphically diagnostic conodont fauna. Most collections are dominated by hyaline forms (Bergström, 1971) such as specimens of *Curtognathus* and *Erismodus*. The ranges of these and other species are given in Figure 5. As a whole, the fauna is quite similar to that of the Black River of New York and coeval strata elsewhere

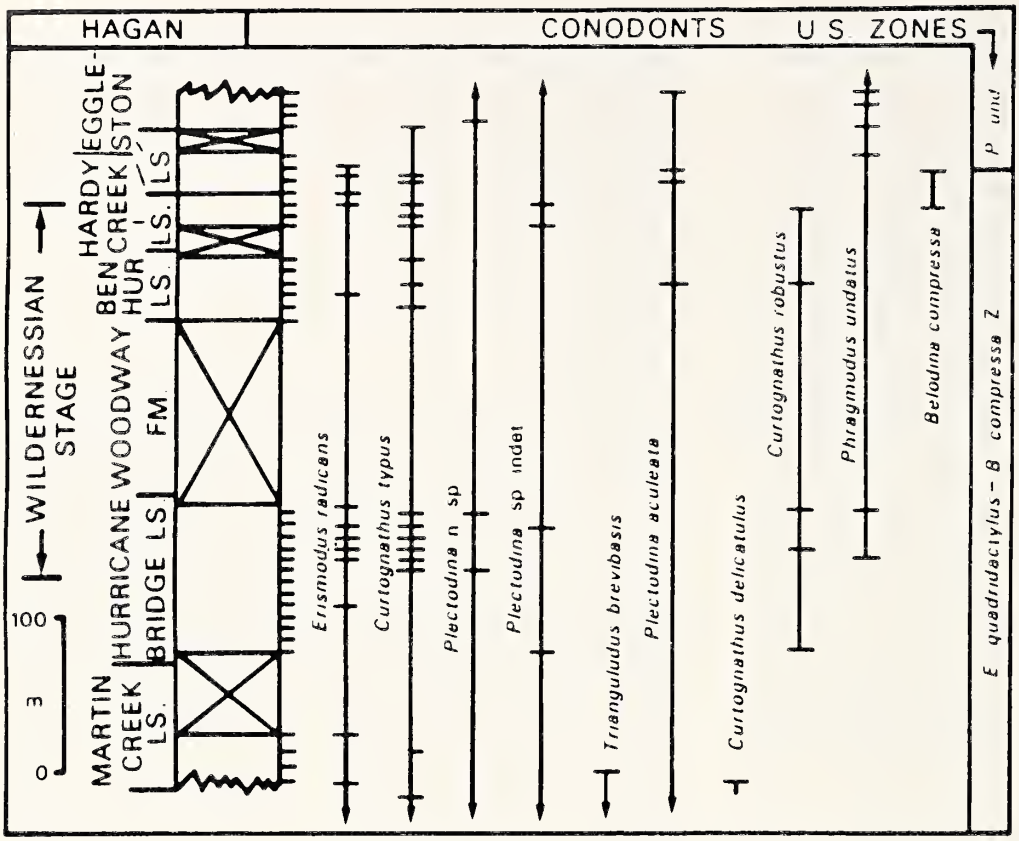


Figure 5

Ranges of selected conodont species through the Wildernessian Stage reference section at Hagan, Virgina. Based on identifications by Hall (1986). A few long-ranging coniform forms (*Drepanoistodus, Panderodus*) and a questionable compound species have been omitted. Note the Midcontinent character of the fauna.

in the eastern Midcontinent (Votaw, 1971). The appearance of specimens of *Phragmodus undatus* in the upper Hurricane Bridge (Hall, 1986) suggests that the Wildernessian is not older than Sweet's (1984) *P. undatus* Zone, and the entire stage may fall within the limits of that zone (Hall, 1986). Alternatively, the *Phragmodus* specimens may represent the poorly known species *P. primus*, originally described from the Joachim Formation of Missouri by Branson and Mehl (1933). The Joachim contains a conodont species assemblage quite similar to that of the type Wildernessian. If this alternative is the correct one, the base of the Wildernessian is older than the *P. undatus* Zone. The age of the top of the Wildernessian is likewise poorly controlled by means of conodonts, but the overlying Eggleton and Trenton limestones contain conodonts suggesting correlation with strata near the Black River-Trenton boundary in New York (Fetzer, 1973).

Shelly Fossils

As indicated above, biostratigraphically useful shelly fossils are virtually absent from the stadial interval at Hagan and elsewhere in the type area, but those few that are present suggest a general correlation with Black River Group strata in New York.

Biostratigraphic Scope of the Wildernessian

As noted above, it is currently not possible to define the scope of the Wildernessian in terms of conodont biostratigraphic units or, for that matter, by means of other fossils. The lower part of the stage may well overlap the upper part of the Ashbyan, and the upper part of the Porterfieldian, but the striking faunal differences make it difficult to prove this possibility.

THE BOLARIAN SERIES

Definition

The term Bolarian Series was proposed as a standard unit by Kay (1947; also Kay, 1948, 1956, 1958) as a replacement for the Black Riveran. The main reasons for this proposed replacement were the fact that there is a stratigraphic gap beneath the Black River in its type area in New York and Ontario and that much of that unit is poorly fossiliferous, making regional correlation difficult. The Bolarian is named for Bolar Valley in Highland County, Virginia. Although no specific type section was given, it is clear from Kay's (1956) description that he based most of his information on a section on hillsides just west of County Road 607 about 3.6 km northeast of the town of Bolar, and this is considered here as the reference section. Indeed, during our studies in the Bolar Valley, we failed to find another section suitable as a reference section, and all our conodont collections are from Kay's section. Kay (1956) included the Ward Cove, Peery, Benbolt, McGlone, and McGraw formations in the Bolarian, but he provided few fossil data for an interpretation of the series in terms of biostratigraphic units. Recently, O'Neill (1985) has described the Bolarian section and its conodont succession (see Figure 6).

Conodont Succession

The Bolarian conodont fauna, which included about 15 species, is dominantly of Midcontinent character although there are a few rare occurrences of North Atlantic species. Of particular biostratigraphic significance is the occurrence of specimens of *Baltoniodus gerdae* about 2 m below and of *Eoplacognathus elongatus* about 6 m above the level of the base of the Bolarian Series. This indicates that the base of the Bolarian is within the *B. gerdae* Subzone and presumably lies in the lowermost part of the subzone. Specimens of *Phragmodus flexuosus* range up to a level about 6 m above the base of the series. Representatives of *Phragmodus inflexus* and *Appalachignathus delicatulus*, as well as "hyaline" forms, are present throughout the 80 m thickness of the series.

Macrofossils

Kay (1956) recorded shelly fossils from several of the Bolarian formations but most of the taxa are not identified to species, and the vertical ranges of these fossils in the Bolarian succession are not clear.

Biostratigraphic Scope of the Bolarian Series

As noted above, the base of the type Bolarian is within the *B. gerdae* Subzone, but the position of the top of the series in terms of North Atlantic conodont zones is not clear. In terms of North American Midcontinent zones (Sweet, 1984), the base of the Bolarian may be in the *P. aculeata* Zone and its top may reach the *B. compressa* Zone. Cooper (1956) interpreted the Bolarian to be

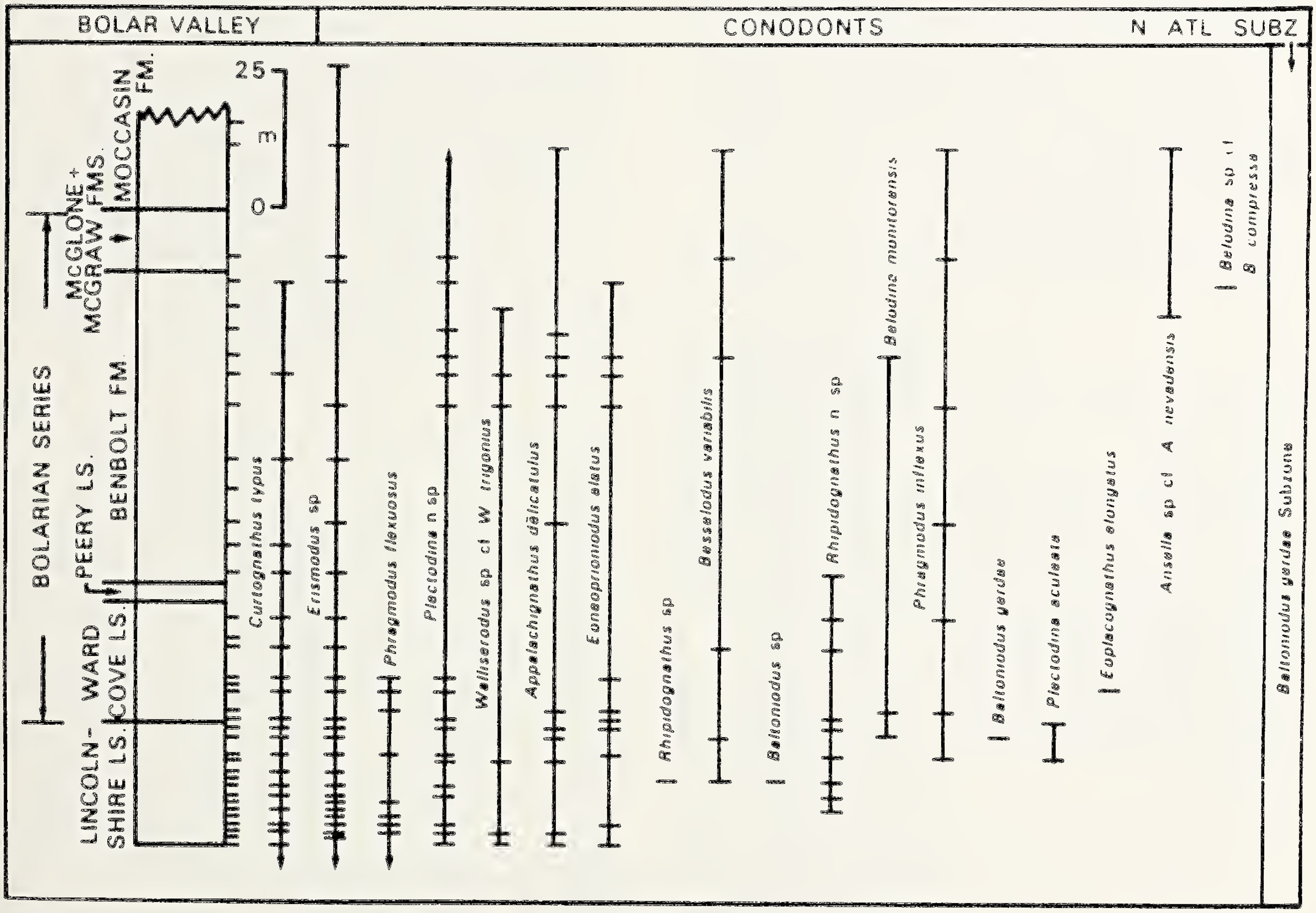


Figure 6 Ranges of selected conodont species through the Bolarian Series reference section in Bolar Valley, Virginia. Based on identifications by O'Neill (1985). Some long-ranging coniform forms (*Drepanoistodus, Panderodus, Pseudooneotodus*) are omitted. Note the presence of *Baltoniodus gerdae* and *Eoplacognathus elongatus* near the base of the Bolarian.

equivalent to his Porterfieldian and Wildernessian stages, but, in our opinion, the lower portion of the type Porterfieldian below the base of the *B. gerdae* Subzone clearly is older than the base of the Bolarian. Kay's (1956) interpretation that the Bolarian corresponds to the Black River Group plus strata missing at the Black River-Chazy unconformity may be essentially correct. However, we believe that the top of the Chazy Group, although admittedly poorly controlled biostratigraphically, is unlikely to be younger than the *Pygodus anserinus* Zone (Sweet and Bergström, 1976).

CONCLUSIONS

Our opinion regarding the stratigraphical scope of the units discussed above is summarized in Figure 7. The vast amount of new conodont information that has become available in recent years confirms the interpretation of Bergström (1971) that Cooper's (1956) stages do not form a continuous succession but rather overlap considerably. Many of the problems in the brachiopod-based correlations result from the markedly diachronous nature of the *Christiania* fauna, the practice of correlating at the generic rather than specific level, and insufficient consideration of the paleoecological and paleobiogeographical differentiation (Jaanusson and Bergström, 1980) of the Appalachian faunas.

The increased precision and resolution of modern biostratigraphy, including the use of graphic correlation methods, require abundant data from stratigraphically closely controlled levels. The common practice in the Appalachians of defining standard units in terms of formations with composite faunal lists needs to be replaced by more precise definitions based on the faunal succession in specific stratotypes. As far as we are aware, this study is the first one that attempts to define the biostratigraphic scope of Cooper's (1956) stages and Kay's (1947) series by means of stratigraphically closely spaced samples from the reference sections. We hope this study will stimulate urgently needed comparative work in the type sections of several other proposed standard units in the North American Ordovician.

ACKNOWLEDGMENTS

We are indebted to H. Jones and K. Tyler for valuable technical assistance and to the Department of Geology and Mineralogy, The Ohio State University, for several grants that covered some of the costs of the present research.

REFERENCES CITED

Bergström, S.M. 1971. Conodont biostratigraphy of the Middle and Upper Ordovician of Europe and eastern North America. Geol. Soc. Amer. Mem. 127:83-157.

__________ 1973. Biostratigraphy and facies relations in the lower Middle Ordovician of easternmost Tennessee. Amer. J. Sci. 273-A:261-293.

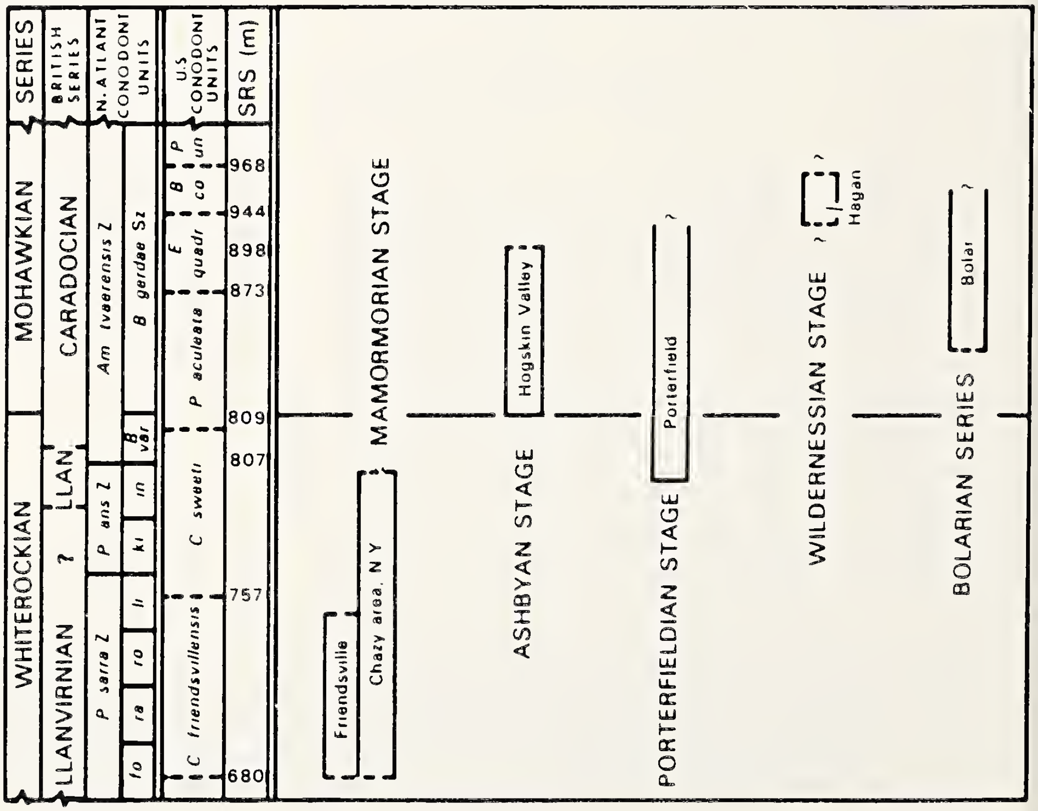


Figure 7

Summary diagram showing the ranges of Cooper's (1956) stages and Kay's (1947) series in their reference sections as suggested by conodont evidence. The North Atlantic zonal scheme follows Bergström (1971, 1983), and that of the U.S. is after Sweet (1984; this volume). SRS values of important boundaries are those of Sweet (1984; this volume).

——— 1983. Biogeography, evolutionary relationships, and biostratigraphic significance of Ordovician platform conodonts. Fossils and Strata 15:33-58.

——— and Carnes, J.B. 1976. Conodont biostratigraphy and paleoecology of the Holston Formation (Middle Ordovician) and associated strata in eastern Tennessee. Geol. Assoc. Can. Spec. Paper 15:27-57.

Branson, E.B. and Mehl, M.G. 1933. Conodont studies number two. Conodonts from the Joachim (Middle Ordovician) of Missouri. Univ. Missouri Stud. 8(2):77-100.

Carnes, J.B. 1975. Conodont biostratigraphy in the lower Middle Ordovician of the western Appalachian thrust-belts in northeastern Tennessee. Doctoral dissertation, Ohio State Univ., 291 pp.

Cooper, B.N. 1953. Trilobites from the Lower Champlainian formations of the Appalachian Valley. Geol. Soc. Amer. Mem. 55:1-69.

Cooper, G.A. 1956. Chazyan and related brachiopods. Smithsonian Misc. Coll. 127, 1245 pp.

——— 1976. Early Middle Ordovician of the United States. *In* Bassett, M.G. (ed.), The Ordovician system: proceedings of a Palaeontological Association Symposium, Birmingham, September 1974. Univ. Wales Press and Natl. Mus. Wales, Cardiff, pp. 171-194.

Decker, C.E. 1952. Stratigraphic significance of graptolites of the Athens Shale. Amer. Assoc. Pet. Geol. Bull. 36:1-115.

Fetzer, J.A. 1973. Biostratigraphic evaluation of some Middle Ordovician bentonite complexes in eastern North America. Master's thesis, Ohio State Univ., 165 pp.

Finney, S. 1977. Graptolites of the Middle Ordovician Athens Shale, Alabama. Doctoral dissertation, Ohio State Univ., 585 pp.

——— 1984. Biogeography of Ordovician graptolites in the Southern Appalachians. *In* Bruton, D.L. (ed.), Aspects of the Ordovician System. Palaeont. Cont. Univ. Oslo 295:167-176.

——— 1985. Nemagraptid graptolites from the Middle Ordovician Athens Shale, Alabama. J. Paleont. 59:1100-1137.

——— 1986. Correlation, graptolite facies, subsidence and eustatic events in Ordovician of Arbuckle and Ouachita Mountains, Oklahoma and Arkansas. Palaios (in press).

Grahn, Y. and Bergström, S.M. 1985. Chitinozoans from the Ordovician-Silurian boundary beds in the eastern Cincinnati region in Ohio and Kentucky. Ohio J. Sci. 85(4):175-183.

Hall, J.C. 1986. Conodont biostratigraphy and facies relationships of the Middle Ordovician in the western overthrust region and Sequatchie Valley of the Southern Appalachians. Doctoral dissertation, Ohio State Univ.

Harris, A.G., Bergström, S.M., Ethington, R.L., and Ross, R.J., Jr. 1979. Aspects of Middle and Upper Ordovician conodont biostratigraphy of carbonate facies in Nevada and southeast California and comparison with some Appalachian successions. Brigham Young Univ. Stud. Geol. 26:7-43.

Jaanusson, V. and Bergström, S.M. 1980. Middle Ordovician faunal spatial differentiation in Baltoscandia and the Appalachians. Alcheringa 4:89-110.

Kay, G.M. 1947. Bolarian Series of the Ordovician (abstract). Geol. Soc. Amer. Bull. 58:1198-1199.

——— 1948. Summary of Middle Ordovician bordering Allegheny synclinorium. Amer. Assoc. Pet. Geol. Bull. 32:1397-1416.

——— 1956. Ordovician limestones in the western anticlines of the Appalachians in West Virginia and Virginia northeast of the New River. Geol. Soc. Amer. Bull. 67:55-106.

——— 1958. Ordovician Highgate Springs sequence of Vermont and Quebec and Ordovician classification. Amer. J. Sci. 256:65-96.

Kurapkat, W. 1986. Conodont biostratigraphy and paleoecology of the Middle Ordovician ramp-to-basin sequence in the thrust belts of southwest Virginia. Master's thesis, Ohio State Univ., 260 pp.

Markello, J.R., Tillman, C.G., and Read, J.F. 1979. Field Trip No. 2: Lithofacies and biostratigraphy of Cambrian and Ordovician platform and basin facies carbonates and clastics, southwestern Virginia. *In* Glover, L., III, and Read, J.F. (eds.), Guides to Field Trips 1-3 for Southeastern Section meeting, Geol. Soc. Amer., Virginia Poly. Inst. State Univ., Blacksburg, Virginia, pp. 43-86.

Moehl, W.R. 1965. A study of the Lenoir Limestones in the Knoxville-Friendsville belt, Knox and Blount Counties, Tennessee. Master's thesis, Univ. Tennessee.

O'Neill, B.E. 1985. Conodont biostratigraphy and paleoecology in the lower Middle Ordovician of the Valley and Ridge overthrust region of West-Central Virginia. Master's thesis, Ohio State Univ., 194 pp.

Raring, A.M. 1972. Conodont biostratigraphy of the Chazy Group (lower Middle Ordovician), Champlain Valley, New York and Vermont. Doctoral dissertation, Lehigh Univ., 154 pp.

Ross, R.J., Jr., and others. 1982. The Ordovician System in the United States. Correlation chart and explanatory notes. Int. Union Geol. Sci. Pub. 12, 73 pp.

Schmidt, M.A. 1982. Conodont biostratigraphy and facies relations of the Chickamauga Limestone (Middle Ordovician) of the Southern Appalachians, Alabama and Georgia. Master's thesis, Ohio State Univ., 270 pp.

Sweet, W.C. 1984. Graphic correlation of upper Middle and Upper Ordovician rocks, North American Midcontinent Province, U.S.A. *In* Bruton, D.L. (ed.), Aspects of the Ordovician System. Palaeont. Cont. Univ. Oslo 295:23-35.

__________ *In press.* Mohawkian and Cincinnatian chronostratigraphy. New York State Mus Bull. 462.

__________ and Bergström, S.M. 1976. Conodont biostratigraphy of the Middle and Upper Ordovician of the United States Midcontinent. *In* Bassett, M.G. (ed.), The Ordovician System: Proceedings of a Paleontological Association Symposium, Birmingham, September 1974. Univ. Wales Press and Natl. Mus. Wales, Cardiff, pp. 121-151.

__________ and __________ 1986. Conodonts and biostratigraphic correlation. Ann. Rev. Earth Planet. Sci. 14:85-112.

__________, Ethington, R.L., and Barnes, C.R. 1971. North American Middle and Upper Ordovician conodont faunas. Geol. Soc. Amer. Mem. 127:163-193.

Votaw, R.B. 1971. Conodont biostratigraphy of the Black River Group (Middle Ordovician) and equivalent rocks of the eastern Midcontinent, North America. Doctoral dissertation, Ohio State Univ., 170 pp.

Whittington, H.B. and Evitt, W.R. 1953. Silicified Middle Ordovician trilobites. Geol. Soc. Amer. Mem. 59:1-137.

Graptolite-Based Correlation of Earliest Ordovician in Eastern North American Marginal Sequences with Coeval Successions in Northern China and Oslo, Norway

Bernd-Dietrich Erdtmann

Institut und Museum für Geologie and Paläontologie, Universität Göttingen

ABSTRACT

Earliest evolution and morphogenesis of nematophorous (planktic) graptolites at the base of the Ordovician may be traced back into the latest Cambrian (Trempealeauan), where a notable increase of "rooted dendroid" (pseudo-planktic) progenitor forms is observed in continuous, distal, continent-margin-facies sequences of Cow Head Group lime mudstones at Green Point and at Martin Point in western Newfoundland. The first nematophorous graptolites appear spontaneously and concurrently in heterotaxial sequences around the world. These are small "pseudoquadriradiate" subhorizontal forms that convergently develop into a subhorizontal lineage (*Staurograptus* of *S. dichotomus* and gerontic ?*Radiograptus flexibilis* types) and into a pendent lineage comprising the (juvenile?) pauci-dissepimentous ?*Rhabdinopora praeparabola* and (mature?) *Rhabdinopora parabola*. Subsequent morphogenetic trends of the earliest nematophorids are directed toward a triradiate proximal development, followed by a "pseudo-biradiate" and, during the earliest "middle" Tremadocian, by a true biradiate development of primary stipes from the sicula, regardless of horizontal or pendent stipe orientation. These profound paragenetic changes of primary stipe origin appear as quasicontemporaneous "biologic events" during the earliest Tremadocian, independent of lithofacies and paleogeographic location. Second order morphogenetic trends are observed in the form of distalward displacements of dicalycal thecae (or dichotomous ramifications) until these disappear entirely from the rhabdosomes (e.g., the *Staurograptus-Aletograptus* lineage). Based on primary and secondary morphogenetic developmental stages ("anagenetic grades") and their unique global correlability, "Assemblages 1, 2A, and 2B" are applied to subdivide early Tremadocian graptolitic strata representing "pseudo-quadriradiate", and triradiate and "pseudo-biradiate" grades of morphogenetic evolution, respectively. Biostratigraphic resolution of the first two of these three "morphogenetic grade zones" currently encompasses a single cordylodan conodont zone, i.e. the interval between the first appearances of *Cordylodus lindstromi* and *C. angulatus*. Zonation based on secondary morphogenetic grade stages, i.e. zones or subzones based on locations of dicalycal thecae in staurograptid or rhabdinoporid rhabdosomes, is premature at present (due to uninvestigated astogenetic factors), but shows promising potentials for even more refined biostratigraphic resolution (of a rough magnitude of 10^4-10^5 years) of early Tremadocian (*Rhabdinopora* interval) time.

INTRODUCTION

This preliminary report is intended to outline and to summarize the author's observations of several months' field work during the summers 1984 and 1985 and of comprehensive evaluations of graptolites collected from 6 major sections (Green Point, Martin Point, Broom Point South and North, St. Paul's Bridge North and St. Paul's Quarry; see Figure 1) in western Newfoundland spanning the Cambrian-Ordovician boundary interval. The identified taxa are listed in the enclosed chart (Figure 2) and a section-to-section correlation is given where possible. Data from Martin Point, Broom Point South and St. Paul's Bridge are not included in this chart (Figure 2), partly because these sections did not contribute new or critical information, or partly, as in the case of Martin Point, graptolite or conodont data appear to be partly lacking and/or inconclusive at this time.

All conodont data from the Newfoundland sections were obtained through C.R. Barnes whose generous support and cooperation is gratefully acknowledged. During the author's section work the sample horizons for conodonts investigated by G. Bagnoli and C.R. Barnes were visibly marked and their positions were later incorporated into the field log. Upon correlation of these data with those of Barnes and Bagnoli at Memorial University in April, 1985, their identifications were copied into this log and then into the chart (Figure 2). All trilobite data are taken from Fortey (Fortey and others, 1982). The subsequent discussion of graptolite data from the Hunjiang area of northern China and from Naersnes near Oslo, Norway, is based on personal observations and collections made during the summer 1985 (at Hunjiang; see Chen and others, 1985) and during many field visits in the Oslo region during the past 25 years. Thanks are due to many colleagues in China and Norway for their kind assistance, to Richard Fortey (British Museum of Natural History, London) for intensive and constructive discussions of the Cow Head Group sections and graptolites, to the Deutsche Fors-

chungsgemeinschaft (Grant Er 96/4-3) as well as to NATO Scientific Affairs Division for research grants to cover field expenses in western Newfoundland, and to "Max-Planck-Gesellschaft" jointly with "Academia Sinica" for having arranged the field visit to Hunjiang.

The comprehensive synthesis given below and illustrated in the included illustrations (Figures 2 and 3) is based upon a detailed morphometric analysis of a great number of well- preserved graptolites. These data, especially a descriptive account of the fauna itself, as well as the resulting interpretations, which are here advanced prematurely-without sufficiently thorough discussion – are presented with the intention to provoke informal debate. Objections and alternative interpretations are herewith invited from all sides.

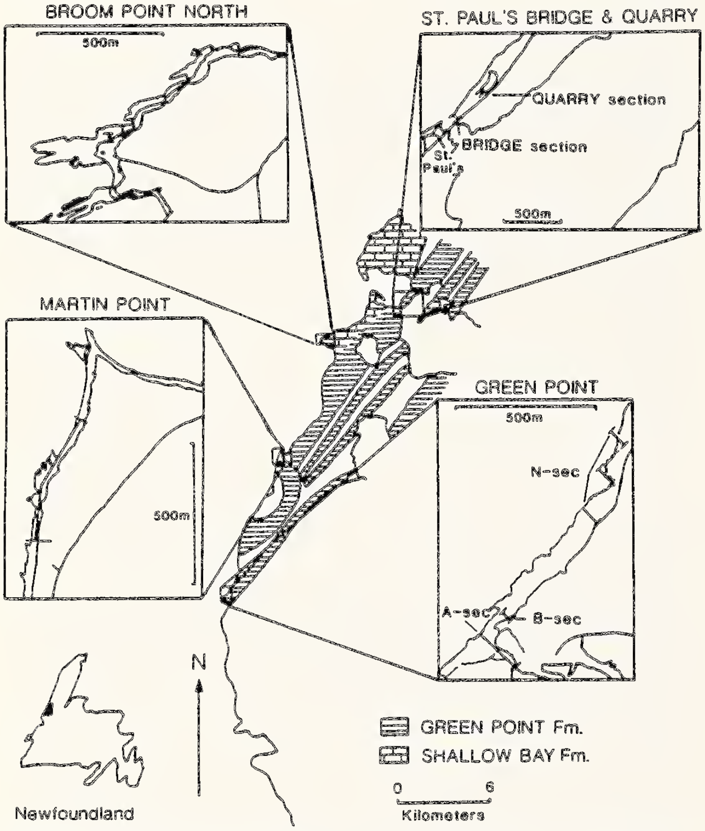


Figure 1 Regional geology and Cambrian-Ordovician boundary sections in the Cow Head Group, western Newfoundland.

BIOSTRATIGRAPHIC SYNTHESIS

Morphogenetic analysis of approximately 1200 well-preserved but mostly flattened graptolites from 6 major coastal sections of the early Tremadocian (early Ibexian) Broom Point Member, Green Point and Shallow Bay Formations, Cow Head Group of western Newfoundland (Figure 2), and of additional material from the coeval Xiaoyangqiao and Muxiantougou sections in the Hunjiang area of Jilin Province, China (Chen and others, 1985), and from the Naersnes sections near Oslo, Norway (Bruton and others, 1982), has rendered the following results and interpretative correlations.

All sections (with the possible exception of Broom Point N and S) are depositionally uninterrupted in the interval between the first occurrence of nematophorous graptolites and the first occurrence of biradiate *Adelograptus* cf. *tenellus-hunnebergensis*. Considering the depositionally instable slope environment of the Cow Head Group in general, where post- depositional and pre-diagenetic "recycling" of sediments and fossils must have been rampant, only the delicate organic graptolites amongst all mineralized fossils could not have survived exhumation and re-transportation, and thus must be assuredly autochthonous. This is important to be kept in mind.

The first nematophorous graptolites of all sections invariably belong to a single "morphogenetic plexus" comprising a so-called "pseudo-quadriradiate" proximal development of both horizontal-discoidal (e.g. *Staurograptus*, *?Radiograptus flexibilis* and *Aletograptus*) and pendent-conical (e.g., *?Rhabdinopora praeparabola*, *R. parabola*, *R. rustica* and *R. flabelliformis-socialis*) "morphs" or "form taxa". All these forms may be found together on the same or on adjacent bedding planes (at Martin Point and Green Point) or segregated presumably due to biotope preferences of these morphs (astogenetically "older", secondarily drifted-in forms are characteristic for the Chinese localities, and selectively pendent forms for the more open pelagic and probably colder water black shale sequence of Naersnes). No specific superpositional stratigraphic ranges can be attributed to the isolated occurrences of these form-taxa at the current state of knowledge (i.e., to *Staurograptus*, *Aletograptus*, *?Radiograptus flexibilis*, *?Rhabdinopora praeparabola*, *R. parabola*, *R. flabelliformis* s. l. and *R. socialis*) because these form-taxa may occur at any horizon within the total range of this morphogenetic plexus. Their segregated occurrence at specific sections representing distinctive lithofacies may only be of bio-environmental significance. All graptolites listed above are "pseudo- quadriradiate," i.e., they possess four "apparent primary" stipes when preserved in dorso-ventral projection, but they usually display an asymmetrical triradiate pattern when preserved in lateral or profile view. At all listed localities this fauna is consistent with "Assemblage 1" of Cooper (1977) and stratigraphically precedes the appearance of a truely triradiate (e.g., in horizontal perspective) morphogenetic plexus consisting of triramous *Aletograptus*, *?Psigraptus* cf. *canadensis*, *Anisograptus richardsoni*, *A. matanensis*, "Matane-type" *?Rhabdinopora* (triradiate *?R. canadensis*, *?R. cristata*, *?R. cyathiformis* or its probable synonym *?R. scitula*, etc.), and of a few first appearances of *Radiograptus rosieranus*. This triradiate form-plexus comprises

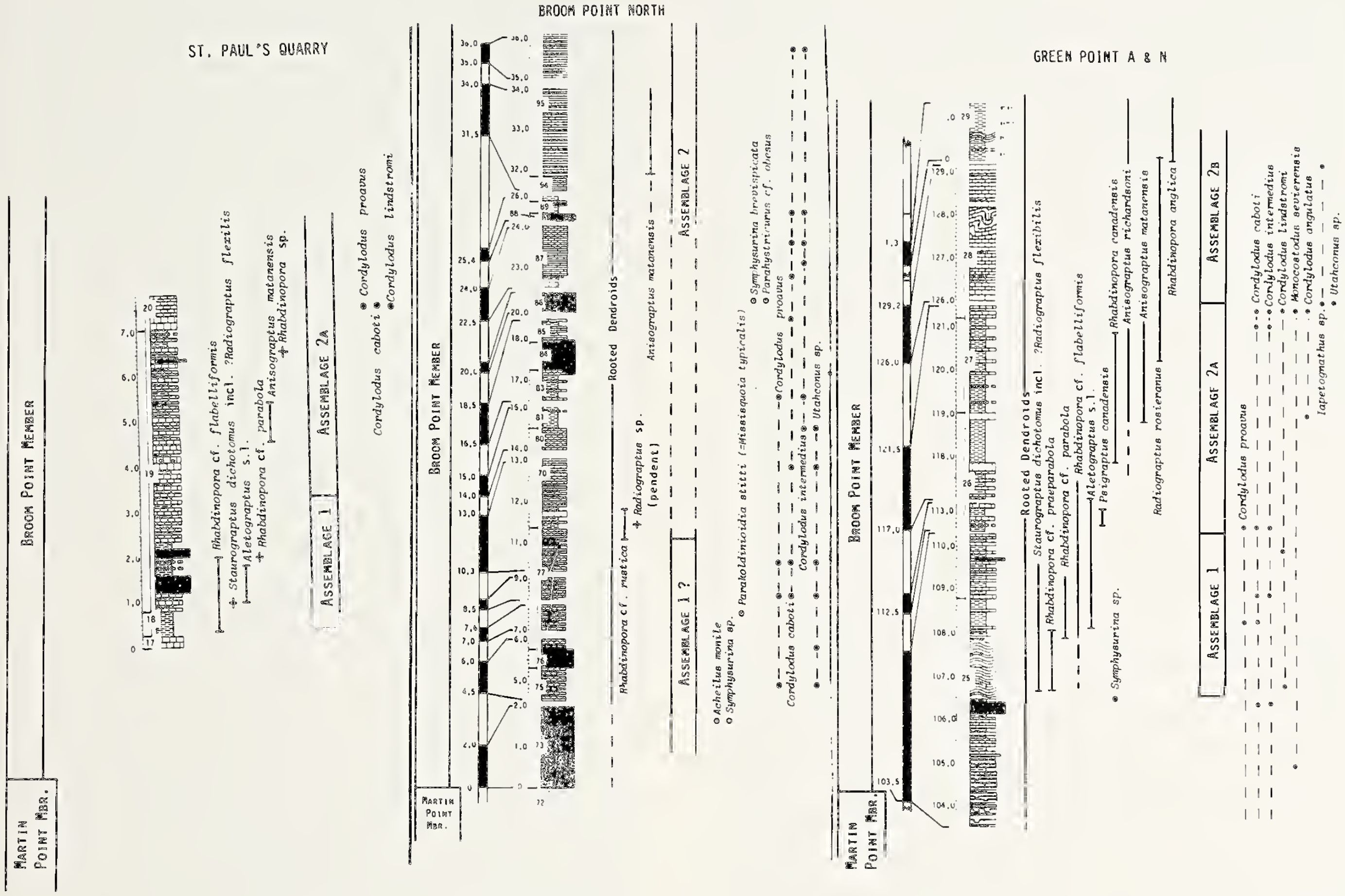


Figure 2 Lithosequence and faunal distributions from selected Cambrian-Ordovician boundary sections, Cow Head Group, western Newfoundland.

"Assemblage 2A" (new zone) to be followed by the less diversified "Assemblage 2B" consisting of *Anisograptus* cf. *matanensis*, ?*A. tetragraptoides*, ?*A. primigenius* (the latter two form-species are "pseudo-biradiate"), *Radiograptus rosieranus*, ?*Rhabdinopora anglica* and (probably gerontomorph) ?*R.* cf. *multithecata* and the open-conical ?*R.* cf. *patula.* The latter two sub-assemblages are characteristic of the depositionally most expanded Green Point sequence, but may, in part or in a condensed succession, also be recognized in all the other Newfoundland sections and in the Hunjiang area and at Naersnes.

The "middle" Tremadocian is universally introduced by a great reduction of morphogenetic diversity to principally two or three lineages, i.e., the biradiate Anisograptidae belonging to the pendent *Bryograptus* and horizontal to deflexed *Adelograptus* (with rare triradiate *Psigraptus* "lingering on"). At the Green Point and Martin Point sections this spontaneous faunal change-over "event" is accompanied by a sudden shift from carbonate mudstones to black shales, the latter apparently representing a stable pelagic environment in which mostly pendent graptolites thrived, not only along the distal slope margins of western Newfoundland, but also elsewhere in coeval ocean-facing and "Black Sea" type facies.

The early Tremadocian graptolite Assemblages 1 and 2 dominated by the quadriradiate *Staurograptus-Rhabdinopora* plexus and followed by the triradiate *Anisograptus-Rhabdinopora* (incl. ?*Psigraptus* cf. *canadensis* and *Radiograptus* s. str.) form-plexi, are found within the interval of the first occurrences of the conodonts *Cordylodus lindstromi* and *Cordylodus angulatus*, the latter starting with Assemblage 2B graptolites at Green Point; i.e., the conodont Subzone of *C. lindstromi* may be divided further into two graptolite assemblage zones (Assemblages 1 and 2A; see Figure 2), or alternatively, when ongoing studies are completed, into several graptolite form-taxa range zones.

No trilobites, not even pelagic olenids or agnostids, were found at Green Point, except for an indeterminable specimen of *Symphysurina* which was recovered by Fortey (personal comm., 1981) from a clast incorporated in a limestone breccia lens at the base of the nematophorous graptolite sequence at Green Point. From the more proximal slope sections of Broom Point N and S (where the nematophorous graptolite sequence is strongly condensed and repeatedly interrupted by the scour exerted by implacement of numerous breccia beds) many trilobites were described, generally from the breccia beds, but also from a few autochthonous limestone beds. The trilobites here include *Parakoldinioidia stitti* (=*Missisquoia typicalis*), *Symphysurina brevispicata*, *Pseudohystricurus* cf. *obesus* and other postsaukiid forms. A high-resolution biostratigraphic zonation corresponding to the graptolite assemblage zones is probably not possible based on these trilobites. In the open-pelagic (or starved basin?) black shale sequences of the Oslo-Scania Depression, *Parabolina acanthura* and *Boeckaspis hirsuta* topped by *Jujuyaspis keideli norvegica* appear to correspond to graptolite Assemblage 1, *Boeckaspis mobergi* to Assemblage 2, and *Peltocare norvegicum* to Assemblage 3 (*Adelograptus-Bryograptus*; see Figure 3). In northern China a more endemic trilobite fauna dominated by *Yosimuraspis*, *Leiostegium* and *Platypeltoides* corresponds to the graptolite Assemblage Zones 1 and 2 (Chen and others, 1985).

To conclude the biostratigraphic synthesis, it may be stated here that the stratigraphic levels or "ranges" of individual typomorphically defined graptolite form-genera or -species would not be proficient to define early Tremadocian graptolite zones or an over-regional scale, but only the composite ranges of "morphogenetic grade assemblages" of sequentially occurring apparent quadriradiate and triradiate nematophorous dendroids may prove to be applicable. Upon conclusion of ongoing investigations it may be possible to distinguish phyletic lineages (based on second order morphogenetic criteria) within *Staurograptus* or *Rhabdinopora* to allow for a more detailed discrimination of discrete evolutionary stages of these groups which may then prove to be correlatable over great distances. The closest links to conodont zonation are possible at the Green Point and Xiaoyangqiao (Jilin, China) sections where graptolite Assemblage Zones 1 and 2A correspond to the interval between the first occurrences of *Cordylodus lindstromi* and *C. angulatus* (Chen and others, 1985). A further subdivision of the graptolite or conodont evolutionary stage ranges may become possible on a local but not, as yet, on an interregional or intercontinental scale. In western Newfoundland, the Green Point section represents the most complete and depositionally expanded succession of graptolites (autochthonous bio-taphotope projection of all astogenetic stages), whereas at Naersnes this succession may also be complete, but is very condensed and represented only by pendent (mostly gerontic) morphs and ecological "generalists" among the graptolites, conodonts and trilobites. At Xiaoyanqiao, in another contrasting facies, this interval is documented by a "punctuated" succession of chemocline-controlled isomorphic death assemblages (mass occurrences) of the first nematophorous Assemblages 1 and 2. The Hunjiang area graptolite beds represent certain (transgressive) depositional events which may possess a potentially high isochronous correlation value within the same facies of a geographically limited region, because these "graptolite concentration beds" are widely dispersed in the Hunjiang (Basin) region (Chen and others, 1985). Biostratinomically, these graptolite depositional facies in the Hunjiang area represent "parautochthonous catastrophic taphotope associations," at Naersnes "autochthonous gerontic biotaphotope associations" and at Green Point and Martin Point "autochthonous juvenile to adolescent bio-taphotope associations."

DISCUSSION OF ANISOGRAPTID MORPHOGENESIS AND CLASSIFICATION

Traditionally, nematophorous (=planktic) dendroids belonging to the family Anisograptidae (inclusive of *Rhabdinopora*) and all graptolites of the order Graptoloidea are classified according to set morphological criteria (Bulman, 1970). These criteria are ranked hierarchically due to their presumed phylogenetic significance. The possession of a nema, for example, unites all planktic graptolites which are believed to have been derived from a common (monophyletic) ancestor: *Rhabdinopora* (formerly *Dictyonema*) *flabelliformis*. Possession of bithecae, then, separates the family Anisograptidae from the non-bithecate graptoloids regardless of quite independent phyletic links between individual taxa of both orders. Suprageneric classification within the Anisograptidae has not been formalized as yet, and conflicting schemes have been proposed (Mu, 1974; Lin, 1981; Erdtmann, 1982a). General agreement may exist as to the significance of the proximal development modes already established in these primitive but very complex planktic graptolites. Unfortunately, isolatable material is extremely rare in this group; therefore details of the complex stolonal ramifications near the sicula are only known from few observations (Bulman, 1927, 1949; Hutt, 1974; Legrand, 1974). Nevertheless, it may be ascertained that the gradual development from a (pseudo-) quadriradiate to a triradiate and then to a biradiate proximal divisional scheme represents a principal evolutionary sequence. This process of primary stipe reduction is also recognized as a general trend, but the "pace" at which first "accidental" (neotenous?) newcomers appear is indeed surprising. The very first nematophorous graptolites may consist of both horizontal staurograptids (incl. dissepimentous forms such as ?*Radiograptus flexibilis*) and pendent rhabdinoporid morphs. This is clearly evident from the lowest nematophorous graptolite beds at Green Point where diminutive horizontal staurograptids are virtually indistinguishable from coeval, slightly pendent, early rhabdinoporids. Already in the top of beds of Assemblage 1 at Green Point (Section B) triramous forms appear, although quadriradiate forms continue for a few more meters. Likewise, specimens of the biradiate tetraramous ?*Anisograptus tetragraptoides* and of ?*Anisograptus primigenius* (a pseudobiradiate and biramous form) occur occasionally in the higher beds of Assemblage 2A at Green Point, although a complete breakthrough of the biradiate scheme is first recognized with the sudden appearance of *Adelograptus* in Assemblage 3. In other words, the entire development from the "invention" of a quadriradiate planktic graptolite to the first appearance of a biramous graptolite occurred within the narrow interval of one conodont subzone (i.e. the interval between the first appearance of *C. lindstromi* and *C. angulatus*).

Conventionally, such factors as stipe habit or "rhabdosomal mode" (pendent, horizontal, reclined, etc., see Elles & Wood, 1902), number and positions of dicalycal thecae which form new stipes, etc. (see Bulman, 1970; Cooper & Fortey, 1982) are regarded as significant taxonomic parameters in addition to shapes and types of thecae. Considering that autothecal and bithecal morphology is fairly constant within the earliest Anisograptidae (*Psigraptus* apparently being the notable exception), there would be a great diversity of rhabdosomal and dicalycal modes displayed by each of the quadriradiate, triradiate and biradiate groups. These two parameters apparently determined, for most graptolite taxonomists until now, the generic and subgeneric rank (for a few oriental authors even about familial rank) of these often cooccurring forms. For example, the discoidal *Radiograptus* and the pendent *Rhabdinopora* would have to be each divided into two independent genera due to either quadriradiate or triradiate habitus analogous to the quadriradiate *Staurograptus* and the triradiate *Anisograptus*. If this typomorphic system of classification is to be applied to the Anisograptidae by adoption of the same parameters which may be applicable to the Graptoloidea, the consequence would be a plethora of new genera and species, as recently exemplified by the systematics proposed for *Psigraptus* by Zhao and Zhang (1985). Instead, it appears to be more convincing to allow for high intraspecific morphogenetic "plasticity" during the earliest stages of nematophorous graptolite evolution, when dicalycal thecae and rhabdosomal modes must have been far less codified by genetics than in the more advanced graptoloids. Cooper and Fortey (1982, 1983) called for a reappraisal of phylogenetically significant parameters in the early Graptoloidea and questioned many of the conventionally applied characteristics and their particular taxonomical ranking. Considering the phylogenetically "unsettled" palette of available parameters for the earliest planktic graptolites, it is quite unlikely that they became so rigidly and hierarchically organized right from the start. As aptly pointed out for the evolution of Graptoloidea by Bulman (1963, figure 3), the Anisograptidae also evolved by a series of anagenetic grades with an early "staurograptid-rhabdinoporid grade." In the future it may be possible to establish numerous clades within this general quadriradiate morphogenetic "fashion trend" during the early Tremadocian, but at present it is more plausible to think of a fairly "broad" genotype control of the newly activated environmental adaptations at this "primitive" stage of planktic graptolite evolution.

PROBLEMS OF EARLIEST ORDOVICIAN GRAPTOLITE CLASSIFICATION AND THE CORRELATION OF COW HEAD GROUP SECTIONS

Recently, Fortey (*In* Fortey and others, 1982) suggested that a horizontally disposed discoidal form close to *Staurograptus* and *Radiograptus* (of ?*R. flexibilis* type) should have been the true ancestral nematophorous graptolite, whereas Erdtmann (1982a), basing his arguments on the uninterrupted Cambrian-Ordovician transition sequence of Naersnes, which lacks these discoidal morphs, proposed the pendent ?*Rhabdinopora praeparabola* and *R. parabola* as the most ancient planktic graptolites. The detailed analysis of the respective sections and contained graptolites in western Newfoundland has revealed that, apparently, both Fortey (*In* Fortey and others, 1982) and Erdtmann (1982a) were partially right and partially wrong in their previous interpretations. The reasons for this are as follows.

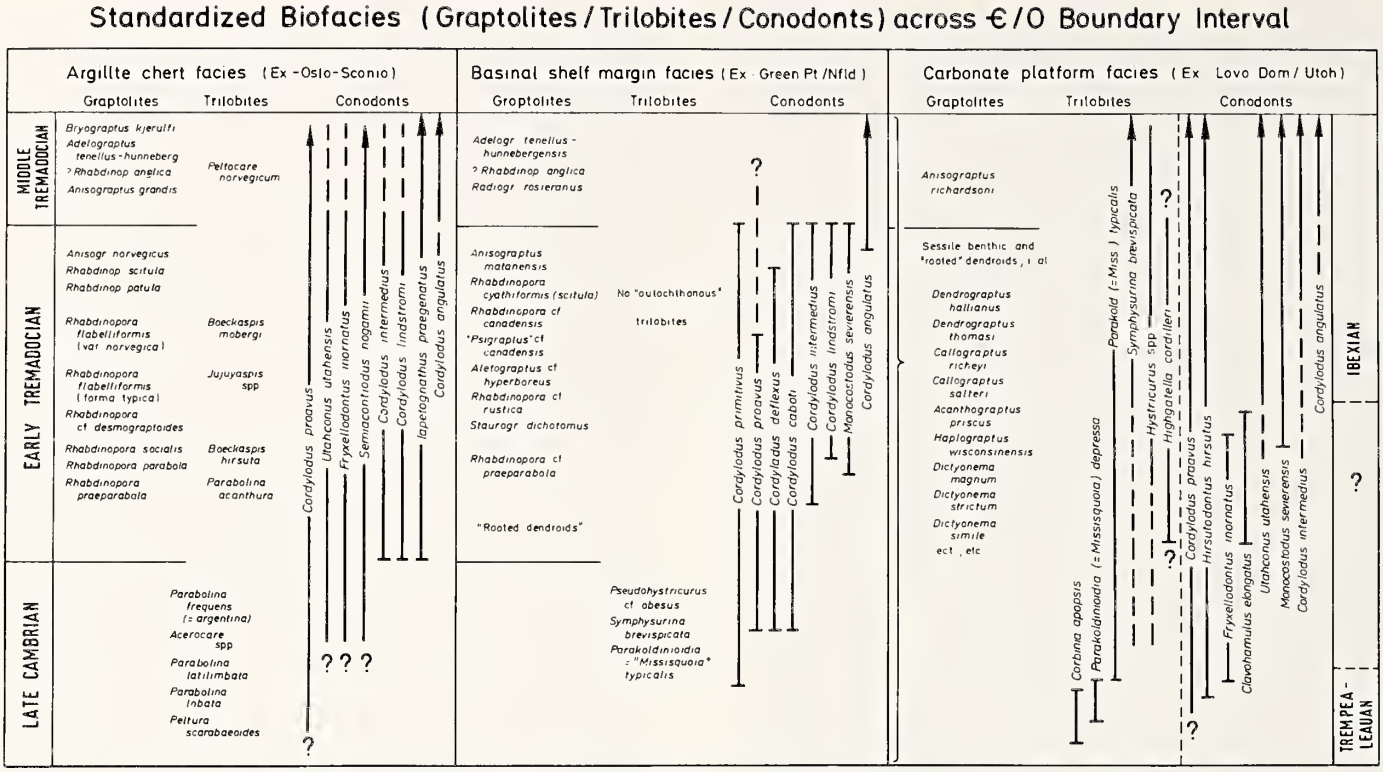


Figure 3 Interprovincial correlation of Cambrian-Ordovician boundary sections.

Early nematophorous graptolites (the family Anisograptidae) display a great morphogenetic "plasticity" with regard to the positioning of dicalycal thecae (=new dichotomous branching) and with regard to the appearance of dissepiments within their rhabdosomes. These features depend upon the astogenetic stages reached at the time of death and probably also depend upon yet unknown ecological factors. Furthermore, the hydrodynamic behavior and subsequent biostratinomical orientation of the dead rhabdosomes on the burial substrate is greatly different for primary horizontal as compared to axially stereosymmetric (=pendent) rhabdosomes (such as *Rhabdinopora* and *Bryograptus*). Bulman (1970) has observed that very young specimens (consisting of a sicula plus only three or four autothecae) of *Rhabdinopora* may either appear in lateral projection, i.e., displaying the full silhouettes of their siculae and first thecae or in dorso-ventral projection, i.e. displaying a dorsoventrally compressed "nipple" for the sicula and four "cross-like" extensions of initial branches (= *Staurograptus* morph). In the lower nematophorous graptolite-bearing beds at Green Point and at Martin Point (to a minor degree also at St. Paul's Quarry) masses of such early stages are observed together with numerous larger forms and fewer very large forms. Regardless of their size, all these graptolites display identical autothecal and bithecal morphologies and show similar cycles of dichotomies (Bulman, 1950) radiating away from the sicula. When laterally preserved, all specimens, again independent of size, show a very dense but distinctly triradiate pattern of stipe origin (see Legrand, 1974, text-figure 5A), but, if preserved in oblique or dorsoventral view, this appears virtually like a "crossbar" as shown by Legrand (1974, text-figure 5B). As succinctly demonstrated by Legrand (1974) for isolated relief-preserved specimens of his "*Dictyonema*" *flabelliforme*, the "quadriradiate" appearance is only the result of an "optical illusion effect" due to the compression of the very dense points of origin for the first four autothecae. Actually, however, there are three initial branches being derived from the first "triad" of stolonal division, and the apparent fourth "primary" branch may have originated from replacement of both initial bithecal buds and the subsequent development of the second triad into a stolonal portion of a new triad. This juvenile proximal development (Legrand, 1974) produces the pseudoquadriradiate proximal pattern found in all Assemblage 1 graptolites regardless of size or astogenetic age.

At various levels within Assemblage 1 at Green Point, Martin Point, and in a far more condensed succession, also at St. Paul's Quarry, bedding-plane assemblages contain "staurograptid" specimens of various sizes together with forms bearing very distal or no dichotomies at all (the latter forms are conventionally called *Aletograptus*). These forms co-occur with still larger dissepiment-bearing forms of *Staurograptus* (which may be related to ?*Radiograptus flexibilis* of Fortey), and these forms are accompanied by larger pendent dissepimentous specimens (*R. parabola*). Excessively large (more than 10 cm axial length) pendent forms of any taxonomic affiliation tend to display "sagging shoulders" (more sharp-angled apical outlines), have denser and thicker dissepiments (for astogenetic control of dissepiment growth, see Erdtmann, 1982a) and thus are identical with *Rhabdinopora flabelliformis* and *R. socialis*. A complete range of astogenetic morphs connecting *R. parabola* and *R. socialis* is observed at Naersnes (Bruton and others, 1982) and in the Berlogaissa Group of Digermul Peninsula, northernmost Norway, but not in Newfoundland. In short, the unifying quadriradiate proximal development, the identical thecal morphology and structure of all these "taxa" listed above and their population-type synchronous (bedding plane) association at several Cow Head Group sections convinces this author that these occurrences may represent phylogenetically closely related form-taxa whose appearances may have been controlled by not yet fully definable ecological and stratigraphical factors. Therefore, for the time being, this author proposes to apply the conventional names (e.g. *Staurograptus*, *Radiograptus*, *Rhabdinopora*, etc.) only in the sense of parataxonomical form-taxa. The first comprehensive morphogenetic plexus is here best referred to as (pseudo-) quadriradiate, and its selective distribution (by certain form-taxa) at specific sections is referred to either presumed ecological (e.g., at Naersnes) or taphonomical (e.g., in the Hunjiang area) control factors. The second evolutionary stage (Assemblage 2A), then, is characterized by a truely triradiate proximal development displaying similar (possibly astogenetically defined) biotope preferences as did their quadriradiate predecessors. The low morphogenetic variability and inconspicuous astogenetic differentiation of early biradiate (pseudobiradiate) Anisograptidae precludes distinction of such facies-controlled associations at the current state of knowledge, but evidence exists from the condensed Baltic and eastern Midlands (Bulman and Rushton, 1973) black shale sequences that pelagic "generalists" such as the large pendent rhabdinoporas of *R. flabelliformis* type (i.e., *R. socialis*, *R. norvegica*, *R. scitula* and *R.? patula*) persisted as late as the middle Tremadocian.

As stated above, the second phase (morphogenetic grade) of early anisograptid evolution is observed as a rather sudden change of proximal development from a (pseudo-) quadriradiate to a triradiate pattern. The first indication of this new triradiate "fashion trend" is seen in the rare occurrence of (pseudo-?) triradiate specimens of *Aletograptus* in the upper part of Assemblage 1 at Green Point, where this development is also best documented. At approximately 6.6 m above the base of Assemblage 1 and near the base of Assemblage 2A, a "band" containing a monotypic occurrence of a reclined triradiate (and triramous) graptolite, here referred to ?*Psigraptus* cf. *canadensis* (possibly synonymous with Ruedemann's, 1947 "*Triograptus osloensis* mut. *minor*" and Bulman's 1950 "*Triograptus canadensis*") is present not only as a laterally continuous "marker band" along the western cliffs of Green Point but also at Martin Point (where this "marker bed" is reduced to a single bedding plane). With the appearance of approximately 2.5 m of "rooted dendroid"-bearing beds, a sudden "burst" of triradiate *Anisograptus richardsoni*, *A. matanensis*, (with rare and later occurrences of pseudo-biradiate *A.? tetragraptoides* and *A.? primigenius*) is observed at Green Point together with equally abundant triradiate "rhabdinoporas" (e.g., ?*R. canadensis*, ?*R. cristata* and ?*R. cyathiformis*). The other "Matane-type" graptolites originally described by Bulman (1950) are also present, but some of these are ill-defined, rare or obviously astogenetic varieties of others (e.g., *Anisograptus flexuosus* is a mature variant of *A. matanensis*). In the upper beds of this new Assemblage 2A, occasional specimens of *Radiograptus rosieranus* s. str. (triradiate with few and very thin dissepiments) are found; a variety of this species appears to be based on a (pseudo-) biradiate proximal end. Very large (more than 15 cm axial length) triradiate rhabdinoporas occur in these beds which are, apart from their triradiate proximal structure, indistinguishable from *R. socialis*. This particular Assemblage 2A is most characteristically developed at Green Point and only "sporadically" seen at the other Cow Head Group sections. A "natural" upper line of Assemblage 2A graptolite occurrences at Green Point is formed by a 7 m-thick ribbon limestone "package" which forms a long intertidal ledge along the shore there and forms the wave-breaking spit of Green Point (see Figure 1). These ribbon limestones contain few graptolites, but they are noted for the first occurrence of the conodonts *Cordylodus angulatus*, *Utahconus*, and other indicative species. The ribbon limestone "package" includes spectacularly slumped interbeds and may reflect a possible minimum sea level stand that appears to correspond to Miller's (1984) "Black Mountain Eustatic Event."

The same event that may have caused the appearance of the ribbon limestones at Green Point may also have had a considerable extinction effect on the graptolite fauna because only a few varieties of *Anisograptus* cf. *matanensis*, a "robust" form of *Staurograptus*, and varieties of *Radiograptus rosieranus* s. str. reappear above this major lithofacial "intermezzo." The triradiate rhabdinoporas have now completely disappeared, but instead, a new rather peculiar "imposter" of *Rhabdinopora* appears together with an assemblage of all intermediate stages between horizontal, deflexed, declined, and pendent varieties of *Radiograptus rosieranus* s. str. This process of "folding-down" from a horizontal-discoidal to a pendent-conical shape, here observable on single bedding planes, is certainly analogous to the same development which Fortey (*In* Fortey and others, 1982, figure 3) had described for the development of the first pendent rhabdinoporas from ?*Radiograptus flexibilis* at the Broom Point South section, demonstrating the significance of repetitive morphogenetic trends in early nematophorid graptolite anagenetic evolution. This particular triradiate pendent morph of *Radiograptus rosieranus* is virtually conspecific with Bulman's (1927, 1949) "*Dictyonema*" *anglicum* from the "Transition Beds" of the Shineton Shales of Shropshire (or from 2e-gamma of the Dictyonema Shales of Oslo, Bulman, 1954). Similar beautifully preserved forms are also observed at a stratigraphically coeval position at Broom Point South (Fortey, 1986, personal comm.). Several "freak" specimens of this pendent "*Rhabdinopora* imposter," however, show that some sinuous stipes from the reverse side of these rhabdosomes are "weaved" into front-side stipes (and vice-versa) and even intertwine with dissepiments. These "disfigured" forms must have been functionally flabellate rather than conical, and this would be evidence for a degeneration of the early Tremadocian conical pattern which apparently had highlighted the rhabdinoporid anagenetic grade during the ranges of Assemblages 1 and 2A. There is good reason to assume that the horizontal *Radiograptus rosieranus*, the transitional open-conical and bell- shaped (or secondarily fan-shaped?) ?*Rhabdinopora anglica* and the similar lose meshes of ?*R. patula* and ?*R. multithecata* from slightly higher horizons belong to a single plexus which is probably not at all related to Fortey's ?*Radiograptus flexibilis* nor to *Rhabdinopora* of either the quadriradiate or triradiate types. It may be of interest to note here that Ruedemann (1947, pl. 4, fig. 25) illustrated a specimen of "*Dictyonema flabelliforme* var. *anglica* Bulman" from Green Point, which was collected by Helgi Johnson in the late 1930's. This "epigonic" group (Assemblage 2B) of "pseudo-rhabdinoporid" graptolites apparently portrays the typolytic phase of the early Tremadocian anisograptid radiation.

Before giving a brief account of the late Tremadocian graptolite beds, a few sentences should be interjected as a comment on *Radiograptus* because this form-genus has generated certain confusion recently. It may be remembered that Bulman (1950) had originally described this discoidal dissepiment-bearing anisograptid from Cap des Rosiers in Quebec. Fortey (*In* Fortey and others, 1982) described a new, distinctly quadriradiate, presumed subspecies of *R. rosieranus* ('*R. r. flexibilis*") from the lowest graptolitic beds at Broom Point S and N and from Cow Head. This author has re-collected material of "*Radiograptus rosieranus flexibilis*" from Fortey's localities and later found such quadriradiate morphs near the base of the graptolitic sequences at St. Paul's (both at the northern bridge rampart and in the quarry section) and at Martin Point. The triradiate "true" *Radiograptus rosieranus*, however, is encountered only, as described above, in the upper beds of Assemblage 2A and in the lower portion of Assemblage 2B at Green Point and reportedly at Broom Point South (Fortey, pers. comm., 1986). Furthermore, as mentioned above, a dissepimentous gerontic morph of *Staurograptus dichotomus* (quadriradiate, of course) occurs infrequently in the lower beds of Assemblage 1 at Green Point. The insertion of dissepiments in large horizontal anisograptids seems to be a gerontomorphic phenomenon, rather than a criterion of particular taxonomic significance. Large gerontic morphs of *Staurograptus* inadvertently develop a problem to keep their distal stipes from touching or crossing one another and therefore tend to "fold down" like an umbrella. The functional need to construct and maintain an open conical shape apparently forced the bithecal or autothecal zooids to secrete dissepiments, which, therefore, must be regarded as astogenetically and/or functionally defined, and not taxonomically relevant characters. The ability to secrete dissepiments was inherited from "rooted dendroid" ancestors of the Anisograptidae and passed on as late as to the La2 appearances of biradiate cone-shaped *Araneograptus* (Erdtmann and Vandenberg, 1985). By analogy with the hypothetically infraspecific transition between discoidal *Radiograptus rosieranus* s.str. and (Pseudo-) *Rhabdinopora anglica*, the gradual "folding-down" development of rhabdosomal shape from horizontal-discoidal to pendent-conical in ?*Radiograptus flexibilis*, as reported by Fortey (*In* Fortey and others, 1982, figure 3) from the Broom Point South section (where this trend occurs sequentially within a short stratigraphic interval) may not reflect a phylogenetic trend but only a morphogenetic (=astogenetic) development within a single staurograptid species. In short, whereas Fortey (op. cit.) suggested that this transition represents a phyletic development between the hypothetical discoidal ancestor and the presumed descendant pendent rhabdinoporas (of *R. parabola* type), field observations and study of the collected material have rendered evidence in support of the hypothesis that the (pseudo-) quadriradiate ?*Radiograptus flexibilis* is a particular (gerontic or possibly facies-dependent) morph belonging to the earliest staurograptid-rhabdinoporid plexus (Assemblage 1) rather than the progenitor of all nematophorous graptolites as was previously claimed. At the present state of knowledge the exact horizon-by-horizon correlation between the Broom Point and other Cow Head Group sections at this particular level (earliest portion of Assemblage 1) is not possible. Moreover, the biofacies (Broom Point N and S are medial to proximal slope sections) and astogenetic constraints of these earliest graptolites are not yet sufficiently understood to permit definitive identification of the "earliest" graptolite morph. Future detailed morphological studies may confirm or disqualify this hypothesis and also bring forth evidence for or against direct phylogenetic relations between the quadriradiate ?*Radiograptus flexibilis* and the triradiate *Radiograptus* s. str. (or *R. rosieranus* type). The first dissepimentous, horizontal quadriradiate graptolite is probably a dissepiment-bearing (gerontic) *Staurograptus* morph, and analogous to this, the triradiate *Radiograptus* s. str. is only a dissepimentous (gerontic) morph of *Anisograptus matanensis* (or of *A. flexuosus*).

At all sections in Newfoundland there appear to be only one or two species characterizing Assemblage 3: *Adelograptus tenellus-hunnebergensis* and *Bryograptus* cf. *kjerulfi* (only one rather indeterminable proximal specimen of the latter was found about 28 m above the ribbon limestone "package" at Green Point North). Both at Green Point and Martin Point, an apparently uninterrupted sequence of green and, higher up, of red laminarites (containing a few thin black shale horizons and occasional limestone breccias) continues upsection, which for an interval of approximately 100 m of strata, includes only sporadic occurrences of "rooted dendroids", phyllocarids and small agnostid or olenid trilobites. Above this virtually "barren" interval, a La2-type fauna containing *Clonograptus*, *Kiaerograptus*, and many other distinctive forms, is found in thin shale interbeds between a few meters of a new ribbon limestone "package". Red and purple mudstones prevail both below and above this La2-interval prior to the first occurrence of *Eotetragraptus approximatus* (La3).

CONCLUSIONS

The probably quite unconventional–and possibly controversial-hypotheses presented here for the explanation of the complex facies-dependent distribution of various morphogenetic and astogenetic graptolite form-taxa at different (heterotaxial) but critical Cambrian-Ordovician boundary stratotype sections may, however, provide a reasonably comprehensive model for clarification of the currently quite confusing graptolite biostratigraphy of this early Tremadocian interval. Many recent observations on graptolite morphogenesis and taxonomy have contributed to this model, such as ideas advanced by Cooper and Fortey (1982, 1983), Fortey (*In* Fortey and others, 1982) and by Erdtmann (1982a, 1982b), but also currently discussed actualistic concepts and models on paleooceanology and paleoecology of extant zooplankton, such as those promoted by Berry and Wilde (1978), Fischer and Arther (1977), Leggett and others (1981), Wilde and Berry (1984), and Berry and others (1985). Of course, alternative explanations of the vexing and certainly rather perplexing taxonomy, biofacies, stratinomy and stratigraphy of early Anisograptidae may appear more plausible than the thoughts presented above may even permit. Therefore, this author would welcome constructive comments, criticism and useful suggestions from all sides.

REFERENCES CITED

Berry, W.B.N. and Wilde, P. 1978. Progressive ventilation of the oceans–an explanation for the distribution of the Lower Paleozoic black shales. Am. J. Sci. 278:257-275.

____________, Wilde, P., and Hunt, M.Q. 1985. The graptolite habitat: an oceanic non-sulfide low oxygen zone? Graptolite Working Group of the International Palaeontological Association, 3rd Int. Conf., 1985, Copenhagen, Abstracts for Meetings, pp. 5-6.

Chen J.-Y., Quian Y.-y., Lin Y.-k., Zhang J.-m., Wang Z.-h., Yin L.m., and Erdtmann, B.-D. 1985. Study on Cambrian-Ordovician boundary strata and its biota in Dayangcha, Hunjiang, Jilin, China. China Prospect Pub. House, 138 p.

Bruton, D.L., Erdtmann, B.-D., and Koch, L. 1982. The Naersnes section, Oslo Region, Norway: a candidate for the Cambrian-Ordovician boundary stratotype at the base of the Tremadoc Series. *In* Bassett, M.G. and Dean, W.T. (eds.), The Cambrian-Ordovician boundary: Sections, fossil distributions, and correlations. Natl. Mus. Wales Geol. Ser. 3:61-69.

Bulman, O.M.B. 1927. British dendroid graptolites. Part I. Palaeont. Soc. Monogr., 28 p.

____________ 1949. A reinterpretation of the structure of *Dictyonema flabelliforme* EICHWALD. Geol. Fören. Stockholm Förhandl. 71:33-40.

____________ 1950. Graptolites from the Dictyonema Shales of Quebec. Quart. J. Geol. Soc. London 106:63-99.

____________ 1954. The graptolite fauna of the Dictyonema Shales of the Oslo Region. Norsk Geol. Tidsskr. 33:1-37.

____________ 1963. The evolution and classification of the Graptoloidea. Quart. J. Geol. Soc. London 119:401-418.

____________ 1970. Graptolithina with sections on Enteropneusta and Pterobranchia. *In* Teichert, C. (ed.), Treatise on Invertebrate Paleontology, Part V. Geol. Soc. Amer. and Univ. Kansas Press, 163 p.

____________ and Rushton, A.W.A. 1973. Tremadoc faunas from boreholes in central England. Bull. Geol. Survey Gt. Brit. 43:1-41.

Cooper, R.A. 1979. Sequence and correlation of Tremadoc graptolite assemblages. Alcheringa 3:7-19.

____________ and Fortey, R.A. 1982. The Ordovician graptolites of Spitsbergen. Bull. Brit. Mus. (Nat. Hist.) Geol. Ser. 36:157-302.

__________ and __________ 1983. Development of the graptoloid rhabdosome. Alcheringa 7:201-221.

Elles, G.L. and Wood, E.M.R. 1902. British graptolites. Part I. Dichograptidae. Palaeontogr. Soc. Monogr. 56(265):55-102.

Erdtmann, B.-D. 1982a. A reorganization and proposed phylogenetic classification of planktic Tremadoc (Early Ordovician) dendroid graptolites. Norsk Geol. Tidsskr. 62:121-145.

__________ 1982b. Palaeobiogeography and environments of planktic dictyonemid graptolites during the earliest Ordovician. *In* Bassett, M.G. and Dean, W.T. (eds.), The Cambrian-Ordovician boundary: Sections, fossil distributions, and correlations. Nat. Mus. Wales Geol. Ser. 3:9-27.

__________ and Vandenberg, A.H.M. 1985. *Araneograptus* gen. nov. and its two species from the late Tremadocian (Lancefieldian, La2) of Victoria. Alcheringa 9:49-63.

Fischer, A.G. and Arthur, M.A. 1977. Secular variations in the pelagic realm. Soc. Econ. Paleont. Mineral. Spec. Publ. 25:1950.

Fortey, R.A., Landing, E., and Skevington, D. 1982. Cambrian-Ordovician boundary sections in the Cow Head Group, western Newfoundland. *In* Bassett, M.G. and Dean, W.T. (eds.), The Cambrian-Ordovician boundary: Sections, fossil distributions, and correlations. Nat. Mus. Wales Geol. Ser. 3:95-129.

Hutt, J.E. 1974. The development of *Clonograptus tenellus* and *Adelograptus hunnebergensis*. Lethaia 7:79-92.

Leggett, J.K., McKerrow, W.A., Cocks, L.R.M., and Rickards, R.B. 1981. Periodicity in the early Palaeozoic marine realm. J. Geol. Soc. London 138:167-176.

Legrand, P. 1974. Development of rhabdosomes with four primary branches in the group *Dictyonema flabelliforme* (Eichwald). *In* Rickards, R.B., Jackson, D.E., and Hughes, C.P. (eds.), Graptolite studies in honour of O.M.B. Bulman. Spec. Papers Palaeont. 13:1934.

Lin, Y.-k. 1981. New materials of graptodendroids with special reference to the classification of Graptodendroidea. Bull. Nanjing Inst. Geol. Palaeont., Acad. Sinica 3:241-262.

Miller, J.F. 1984. Cambrian and earliest Ordovician conodont evolution, biofacies, and provincialism. Geol. Soc. Amer. Spec. Paper 196:43-68.

Mu E. 1974. Evolution, classification and distribution of Graptoloidea and graptodendroids. Sci. Sinica 17:227-238.

Ruedemann, R. 1947. Graptolites of North America. Geol. Soc. America Mem. 19, 652 p.

Wilde, P. and Berry, W.B.N. 1984. Destabilization of the oceanic density structure and its significance to marine "extinction" events. Palaeogeog. Palaeoclim. Palaeoecol. 48:143-162.

Zhao X.-l. and Zhang S.-x. 1985. Reclined graptolites of the Xinchangian. J. Changchun College Geol. 1985 (2):13-26.

The International Correlation of the Lower Part of the Ordovician and How it Should Influence Laurentian Chronostratigraphy

Richard A. Fortey
Department of Palaeontology
British Museum (Natural History)

ABSTRACT

It is urged that stage level chronostratigraphic divisions appropriate to the Ordovician Laurentian continent should take into account international usage. In particular, bases of stages should coincide as closely as possible with the base of the Arenigian and Llanvirnian Series of the Welsh standard; international correlation problems at these horizons should act as a stimulus for further research. Stage nomenclature should be conserved, even if this means moving a stratotype for its base well away from the area that gave the stage its name. The Laurentian paleocontinent should be considered as a whole for candidates for the best sections for stratotypes. The base of the Middle Ordovician (and the Whiterockian Stage) should correlate with the base of the Llanvirnian Series. The equivalents of the Arenigian Series in Laurentia can be usefully divided into two or, in my view, preferably three stages that broadly correspond with a tripartite division in the type area and in the oceanic graptolitic facies. The youngest of these divisions is the Valhallan.

INTRODUCTION

In considering how the chronostratigraphic divisions of the Ordovician ought to be defined in North America, I believe that it is important to have an eye on international usefulness and acceptance. As one who has a scientific interest on both sides of the Atlantic, I am impressed by the need for international convenience in both stratigraphic nomenclature and in the definition of boundaries. Boundaries are, in the last resort, artifacts produced by the co-operation of stratigraphers; we do actually have the freedom of choice to define units in ways that will enlighten rather than confuse those working in other parts of the world. Historical precedence has its part, of course, but because we are now at a time when we are not rigidly bound by the conventions of the past, let us make decisions that will help, rather than hinder, international understanding. The purpose of this note is to offer some reflections on this problem concerning the earlier part of the Ordovician, and especially the Arenigian-Llanvirnian interval on which I have worked extensively.

CONSIDER ALL LAURENTIA AS AVAILABLE FOR STRATOTYPES

Now that plate tectonic theory has edged across the divide that separates the contentious from the factual, it is appropriate that stratigraphic reasoning should relate directly to paleocontinental configurations rather than current national boundaries. As far as the Ordovician is concerned, this means that sections will be available to contribute information or, if need be, become standards over the whole of the Laurentia for this interval. This will include Arctic Canada, Greenland and Spitsbergen. While it is obviously convenient to have boundaries defined within a restricted area—say the western U.S.A.—for reasons of access, it is surely more scientifically important to locate sections that offer the very best control across critical intervals. Just as British geologists are prepared to have a type section for the base of the System removed from the classic area, there is no reason why the base of the Cassinian Stage should not be defined away from Fort Cassin.

NOMENCLATURE SHOULD BE CONSERVED

It follows that the names of chronostratigraphic units do not have to be rigidly tied to the areas where their names were first coined. Names come into common usage for a variety of reasons, not all of them scientific. This does not matter. What is important is that the concept behind the name can (and should) be capable of refinement; stratotype bases may well be moved away from the area that provided the name, but this is no reason to change the name itself. Again, one might invoke the avoidance of confusion on the international scene, and not just with other paleontologists and stratigraphers but with geophysicists and sedimentologists, who care more for consistency than novelty. Equally, it seems worthless to resuscitate old, half-forgotten names that happen to be based on some region of study and attempt to breathe life in them until they become candidates to oust an older, familiar and refineable name. Stratigraphy is not bound by the laws that restrain zoological taxonomy. There is plenty of scope for reasonable nomenclatorial decisions that will leave other geologists enlightened rather than perplexed. To this extent, I regret the eclipse of the Canadian, not because its base is better defined in the Ibex area (it surely is), but because a shift of location does not have to entail a change in name. The meaning of a name can be refined without abandoning it. We have recently discovered that the Arenigian at the type locality (Arennig Fawr in North Wales) is woefully incomplete, but I hope nobody will suggest that we change the name of the Series to Carmarthenian because the rocks are more fully developed around Carmarthen in South Wales.

LAURENTIAN BOUNDARIES SHOULD COINCIDE WITH THOSE USED ELSEWHERE

Base of Middle Ordovician

When I proposed the Valhallan Stage as an uppermost division of the Lower Ordovician (Fortey, 1979, 1980a), it was with one purpose in mind. Thus constrained, the base of the Middle Ordovician was believed to approximate with the base of the Llanvirnian Series of the type Ordovician development in Wales. This seemed to be then, and seems now, a thoroughly desirable goal in stratigraphy—to make boundaries coincide, as far as possible, between different paleogeographic settings. Whether we like it or not, the British standard sequence of Series has been applied everywhere—from South America, to China and Russia—and generally with success. With such a common language available it makes equally common sense to attempt to erect boundaries of continent-wide chronostratigraphic units so that they coincide, at least as closely as possible, with the standard divisions.

There are problems with this desirable goal that are now becoming familiar; "things happen" at the Series boundaries – many of us believe that the boundaries were climactic times of eustatic change that produced the very changes that our predecessors used as the basis for recognizing the divisions in the first place. Continuous sections, and especially confacial ones, will be difficult to find spanning these intervals and will be confined to exterior sites relative to the main continental masses of the time. This can be irritating and can provoke several responses. One that seems to be increasingly common is that boundaries are moved away from these likely times of disconformity in platform sediments, either somewhat up or down. So, for example, the recent Correlation Chart of Ross and others (1982) includes the Valhallan—that awkward late Arenigian portion that is difficult to recognize in platform sequences—with the Whiterockian, and hence with the Middle Ordovician. This seems to me to be a device simply to shuffle the problem out of the way. Curiously, the Whiterockian has been a regular recipient of such juggling. Having started life as the approximate equivalent of the Llanvirnian Series, it has had to accommodate the boundary with the Arenigian below, and now, probably, with the Llandeilian above. It grows, and as it grows, it apparently consumes problems.

The problems do not disappear, of course. Such shuffled boundaries make for problematic international correlations, and nobody seems to agree quite how low or how high they should be taken.

On the international scale the base of the Llanvirnian has proved a recognizable horizon in many areas that were widely separated paleogeographically. It has to be admitted that trilobites have proved useful only for correlation on a fine scale within a single paleoplate, but graptolites and conodonts have proved their worth internationally. The lower boundary of the Llanvirnian has been recognized with some confidence in China (e.g., Mu and others, 1979), western Australia (e.g., Legg, 1976), and in most areas of Ordovician Gondwanna from Saudi Arabia westwards to Bohemia, Armorica and Iberia. On the Baltic plate, graptolitic sequences in Scania and Óland permit correlation of this horizon (via trilobites) into platform sequences in which graptolites are rare. In the oceanic black shales of what has been termed the "Pacific province," graptolites are frequently the only fossils. Similarly, a basal Llanvirnian horizon has been recognized in southern Australia (Victoria), New Zealand, southeast China, as well as the North American sites in the Marathon, Nevada, Idaho, Canadian Rockies, western Newfoundland, etc. There is growing evidence that graptolites in deeper water, more oceanic sites included species that were genuinely cosmopolitan even in the earlier Ordovician when "provinciality" was at a maximum. Some important events in graptolite evolution near the Llanvirnian boundary, such as the first radiation of biserial scandent species, are a bonus for that series' recognizability. In short, the base of the Llanvirnian has proved a convenient as well as a traditional datum, and there is evidence to suggest that graptolites may serve for its refinement.

At the zonal level, there certainly are problems to be resolved. For example, R.M. Owens and I recently have completed a study on the Arenigian Series in its type development in Wales which shows that biserial graptolites make their appearance there *before* the base of the Llanvirn, a situation like that in southwestern China. How this relates to the base of the Darriwilian (the base of the "Pacific province" Middle Ordovician) which is marked *by* the incoming of biserials is as yet uncertain. These problems do suggest the direction in which future research should be focussed.

For Laurentian chronostratigraphy, the conclusion is that a sensible and practical base for the Middle Ordovician ought to coincide as nearly as possible with the base of the Llanvirnian. What this means is that the base of the Whiterockian should be defined in some Laurentian section (not necessarily in Whiterock Canyon) that spans the Arenigian-Llanvirnian boundary in continuously fossiliferous strata and lacks suspicion of hiatus. This probably rules out much of the eastern seaboard of the United States where the Valhallan regression was augmented by tectonics (although I am told that continuous sections with sparse midcontinent conodont faunas probably do exist). Candidates probably will be found in the Cow Head Group, in the more exterior sites in the western United States studied by Ross and colleagues, and in northwestern Canada.

BASE OF THE ARENIGIAN IN RELATION TO LAURENTIA

There will be a similar problem in the definition of a chronostratigraphic boundary in the North American Ordovician that can be correlated with the base of the Arenigian Series. The correlation problems are more acute at this horizon than at the base of the Tremadocian or the base of the Llanvirnian because cosmopolitan index species are virtually unknown and graptolites are not adequately studied near the Tremadocian-Arenigian boundary. Nevertheless, the Arenigian is clearly the match of any other Ordovician series in duration, and its equivalents in North America will require chronostratigraphic characterization. The Cassinian Stage is one available name for the earlier part (at the least) of the Laurentian Arenigian. The type sections in the Fort Cassin area of Vermont include cephalopods and trilobites that indicate a correlation with the classic late "Canadian" faunas of the western Newfoundland platform described by Billings and recently revised by Flower and myself. These in turn are assuredly of Arenigian age because (among other reasons) of their known inter-relationships with graptolitic sediments in the Cow Head Group and on the basis of conodont evidence. There is apparently no shelly later Arenigian (Valhallan) in the platform rocks of either area, however. The base of the Cassinian does not have to be drawn in the area that gave it its name and better sections exist in Utah and Nevada. It may prove desirable to divide the pre-Valhallan Arenigian into two stages; if this is done, the name Jeffersonian is already in use for the pre-Cassinian interval. Whatever is finally adopted, it is to be hoped that the base of the Cassinian or Jeffersonian will coincide with the base of the Arenigian as nearly as is feasible because of the correlation problems at this horizon.

It is important to add that the precise base of the Arenigian Series itself has yet to be formalized. Some twenty years ago David Skevington suggested that the base of the *Tetragraptus approximatus* Zone would have afforded a widely recognizable horizon for the boundary. This suggestion is equally attractive today (and agrees, in general, with Scandinavian usage). A stumbling block was seen as the lack of proof for the equivalents of this zone in the type area. Whittington and others (1984) noted the general inadequacy of the Welsh sections spanning the Tremadocian-Arenigian boundary interval. However, recent discoveries in the Lake District (Rushton, 1985) show that late Tremadocian rocks are present there, and it is very likely that there are continuous sections in that area that span the two series (although even the most chauvinistic Englishman would confess to the scarcity of fossils). Owens and I have suggested that the absence of the zonal index fossil in North Wales might be a matter of paleogeography (rather than lack of time-equivalent rocks) because *T. approximatus* is confined in its occurrence to areas of relatively low paleolatitude. In this it resembles the distribution of *Staurograptus* in the early Tremadocian. Whatever the final outcome over the site of definition of the base of the Arenigian Series, there is every reason to be sanguine about the choice of the base of the *T. approximatus* Zone as the horizon.

As regards the number of divisions into which the Laurentian Arenigian should be divided, arguments can be advanced that suggest a minimum of two and a preference for three stage divisions. Such divisions must be useful for continent-wide discussions of major events.

1) The paradigm for stages, such as those in use for the Jurassic, suggests a duration of 4-6 my. Recent estimates of absolute duration of the Arenigian Series, such as that just published by the Geological Society of London, would indicate that two generous or three slightly short stages could be accommodated within the Arenigian interval. Incidentally, based on this criterion, the British stages of the Caradocian and Ashgillian Series would be an order of magnitude too short (Chlupac and others, 1981).

2) Our restudy of the Arenigian in its type development in Wales has revealed a hitherto unsuspected variety of shelly fossils and a complete and thick succession. On this basis, we have established a threefold division of the British Arenigian Series which it is hoped will be of service in Ordovician sequences that were deposited at high paleolatitudes. A match elsewhere with such a tripartite division is desirable.

3) In purely graptolitic sequences, based on the Victoria, Australia, succession, an essentially fourfold stage division has been employed successfully for many years: Bendigonian (I include topmost Lancefieldian therein), Chewtonian, Castlemainian and Yapeenian. Graptolite sequences the world over can be placed readily within this sequence. The Yapeenian is relatively short, and whether the Llanvirnian boundary should be placed above it or within it is not finally resolved. The latter consideration reduces us once more to a fundamental, tripartite subdivision of the Arenigian sequence (Cooper and Fortey, 1982).

4) Single trilobite species (for example, bathyurids) that are useful for fine (zonal) chronostratigraphic subdivision have geographic ranges in platformal successions that range from one end of Laurentia to the other, from the high Arctic to the southern United States. I have found such species in lower, middle and upper Arenigian rocks. Once correlations by such species are established and supported by conodonts, there seems every prospect of applying genuinely useful stage divisions to examine the broader aspects of the history of the platform.

I would conclude that (1) it would be profitable to establish stage divisions in Laurentia that emphasize a two- or (preferably) three-fold division of the Arenigian Series, (2) the base of the appropriate stage in Laurentia should coincide with the base of the Arenigian, and (3) existing terminology (e.g. Cassinian, Jeffersonian, Valhallan), with appropriate redefinition of stage bases, may be adequate to serve this purpose.

STATUS OF VALHALLAN

It is now possible to return briefly to the Valhallan Stage. This would be the youngest stage division of the Arenigian Series. It was originally proposed to account for a period during which shelly faunas are very poorly represented on the North American craton as a result of a proposed late Arenigian regression. Along the eastern seaboard the Valhallan "gap" was augmented by tectonic activity in many areas. The concept was based on richly fossiliferous successions in Spitsbergen (then part of Laurentia) which was appropriately situated to escape the effects of the regression. Three successive trilobite faunas, two in the same biofacies, indicated that the time represented was sufficient to merit stage recognition while graptolites in the same beds permitted its correlation with other regions and facies (Fortey, 1980b). All of these faunas have been monographed in detail (but not the conodonts, which are in the hands of C.R. Barnes).

As far as I am aware, the existence of the regression at the end of the Arenigian has not been challenged (see Compiler's Note at end). Equivalents of the Valhallan can be recognized in certain appropriately peripheral sites around the Laurentian craton. These include the Cow Head Group, western Newfoundland (Bed 13); the

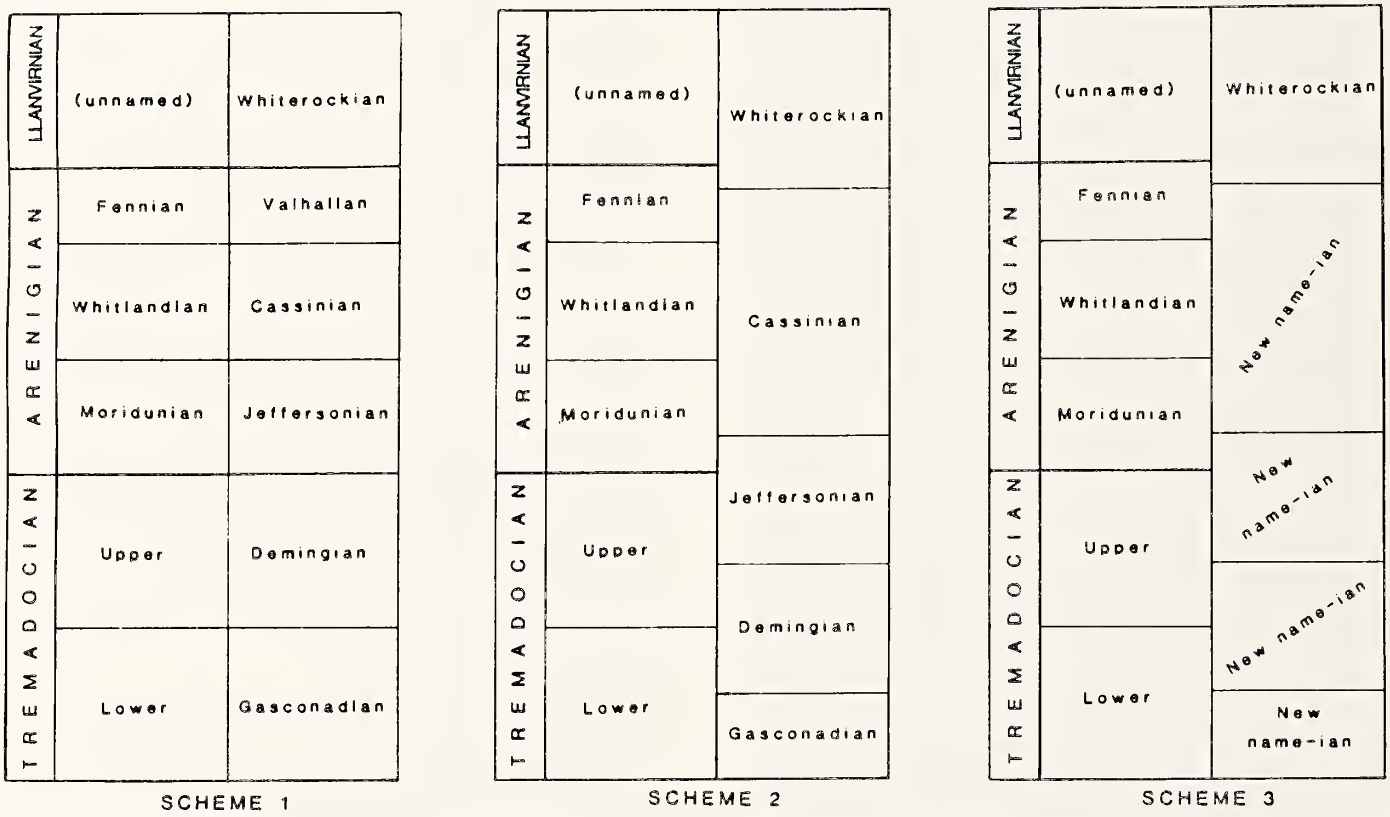


Figure 1 Three potential schemes for the international correlation of the earlier Ordovician, between Laurentian chronostratigraphic units and the classical Welsh divisions. Stage terminology for the Arenigian is from Fortey and Owens, 1987: Bull. Brit. Mus. (Nat. Hist.) 10. Scheme 1 – argued for in this paper, nomenclature is conserved, and bases of Laurentian divisions are chosen to coincide with major divisions in the type area. Scheme 2 – nomenclature is conserved but chosen stratotype bases have little application internationally. Scheme 3 – neither nomenclature nor international usefulness is considered in erecting an entirely new chronostratigraphic scheme.

Road River Formation, western Canada; (probably) western Nevada; Franklinian "geosyncline," northern Greenland; and the Trondheim Region, Norway. In none of these sites are the rocks as fossiliferous as they are in Spitsbergen and lack the prolific graptolite/trilobite/conodont/cephalopod combination.

If a two-fold division of the Laurentian Arenigian is ultimately accepted, having the Valhallan as one of these divisions would make the scale decidedly lopsided because it consists only of the late part of the series (later Castlemainian and Yapeenian in graptolite terms). On the other hand, a three-fold stage subdivision would make the Valhallan the approximate equivalent of the two stages below it. Because a three-fold division is favoured for other reasons, this approach seems preferable. Nothing can be done to relocate the type section, but discovery of a suitable parastratotype in one of the accessible Laurentian areas less affected by the regression is to be anticipated. Once again, the concept is more important than the nomenclature. For reasons listed above, the incorporation of this interval with the Whiterockian is not favored in an international context.

SUMMARY

Sensible chronostratigraphic subdivision of the earlier Ordovician in Laurentia should be (1) internationally compatible with other standard divisions, especially the Tremadocian, Arenigian and Llanvirnian Series and (2) nomenclatorially conservative. However, bases may be redefined away from unsatisfactory type areas to increase precision in correlation. The base of the Whiterockian should coincide, if possible, with the base of the Llanvirnian wherever that base is finally defined. Laurentian equivalents of the Arenigian Series will require division into two, or preferably, three stages, of which the Valhallan is the youngest. Figure 1 shows some of the differences between what should be considered a sensible solution to such stratigraphic problems, and some less sensible alternatives. Unfortunately, some of the published solutions rather resemble the latter.

REFERENCES CITED

Chlupac, I., Flugel, H., and Jaeger, H. 1981. Series or stages within Palaeozoic Systems? Newsletters in Strat. 10:78-91.

Cooper, R.A. and Fortey, R.A. 1982. The Ordovician graptolites of Spitsbergen. Brit. Mus. (Nat. Hist.) Geol. Bull. 36:157-302.

Fortey, R.A. 1980a. The Ordovician of Spitsbergen and its relevance to the base of the Middle Ordovician in North America. *In* Wones, D.R. (ed.), The Caledonides in the USA. Dept. Geol. Sci., Virginia Poly. Inst. State Univ. Mem. 2, pp. 33-40.

__________ 1980b. The Ordovician trilobites of Spitsbergen, Part III. Skr. Norsk Polarinst. 171:1-163.

__________ and Owens, R.M. 1987. The Arenig Series in south Wales. Bull. British Mus. (Nat. Hist.) 41.

Legg, D.P. 1976. Ordovician trilobites and graptolites from the Canning Basin, western Australia. Geol. et Palaeont. 10:1-58.

Mu, E. and others. 1979. Lower Ordovician graptolites of Southwest China. Palaeont. Sinica 156B:1-192.

Ross, R.J., Jr., and others. 1982. The Ordovician System of the United States. Int. Union Geol. Sci. Pub. 12, 73 p.

Rushton, A.W.A. 1985. A Lancefieldian graptolite from the Lake District. Geol. Mag. 122:329-333.

Whittington, H.B., Dean, W.T., Fortey, R.A., Rickards, R.B., Rushton, A.W.A., and Wright, A.D. 1984. Definition of the Tremadoc Series and the series of the Ordovician System in Britain. Geol. Mag. 121:17-33.

COMPILER'S NOTE

A recently submitted report (Landing, E., Benus, A.P., and Whitney, P.R., Early and early Middle Ordovician continental slope deposition: Shale cycles and sandstone deposition in the Quebec Reentrant and New York Promontory Region, *to* Can. J. Earth Sci.) equates the lower Whiterockian with the uppermost Arenigian and considers the late Arenigian as a time of maximum onlap, and not regression).

Cambrian-Ordovician Boundary in North America: Revised Tremadocian Correlations, Unconformities and "Glacioeustasy"

Ed Landing

New York State Geological Survey, The State Education Department

ABSTRACT

Conodont-based correlations have served to raise the level of the Cambrian-Ordovician (Olenidian-Tremadocian Series) boundary into higher levels of the North American Canadian Series. Data from Newfoundland, eastern New York, Norway, and China indicate that the immigration events of earliest Tremadocian dendroids fall within the lower part of the lower conodont Fauna B interval. The *Missisquoia* and lower *Symphysurina* Zones must be regarded as Cambrian. Unfortunately, environmental control of conodont species' distributions is so severe that a conodont-based standard for correlation of the boundary interval is inappropriate. A stratotype featuring overlapping ranges of lower Fauna B conodonts and the lowest ranges of taxonomically well-differentiated planktic *Dictyonema* subspecies is recommended.

The Cambrian-Ordovician boundary is regionally disconformable in North America due to long-term Late Cambrian eustatic fall and restriction of boundary-interval deposition to marginal and middle carbonate platform settings. The sub-Tremadocian disconformity within the latter facies belts is local and is best interpreted by off-lap due to short term decrease in rate of sea level rise. Subsequent Tremadocian on-lap beginning in early Fauna B-time reflects a more gradual rise in sea level than that proposed by glacioeustatic models. Strong climate differentiation and boundary interval glaciation must be questioned because of the absence of known glacial sediments and the apparent thick dysaerobic layer of the world ocean. Evidence for the "Black Mountain Eustatic Event" is not considered credible and the "BMEE" would be older than the middle-late Tremadocian boundary interval if it existed.

INTRODUCTION

The Tremadocian generally is regarded as the lowest series of the Ordovician in the classical biofacies of the Cambrian and Ordovician Systems in northwestern Europe (see Henningsmoen, 1973). The practical and physical base of this series is frequently taken at a horizon marked by the sudden immigration of early planktic *Dictyonema* species (=*Rhabdinopora* of Erdtmann [1983]) in the siliciclastic-dominated sequences of the Avalonian Platform and in the similar biofacies of the Baltoscandian Platform (see Skevington, 1964). A slightly lower horizon is included in the Tremadocian at Naersnes, near Oslo, Norway, where the olenid trilobite *Boeckaspis hirsuta* (Brögger 1882) occurs in calcareous nodules located both slightly below (ca. 20 cm) and within the local range of planktic *Dictyonema*. This trilobite, consequently, has been regarded as an element of a Tremadocian fauna and sub-*Dictyonema* shales have been referred to the Tremadocian at Naersnes (Henningsmoen, 1957; Bruton and others, 1982).

Interprovincial correlation of the Cambrian-Tremadocian boundary into North America has long been problematical because planktic *Dictyonema* faunas long remained unreported from North American sequences. In addition, trilobites are nearly mutually exclusive at the family level between North America and northwestern Europe (Henningsmoen, 1957, 1969).

Successive improvements have taken place on the resolution of the location of the Cambrian-Tremadocian boundary interval in North American sequences (Landing and others, 1978; Fortey and others, 1982) and provide a certain academic satisfaction. In addition, new information has been provided on the temporal and geographic distribution of marine biotas and on lithofacies and depositional environments in the latest Cambrian and earliest Ordovician (see Bassett and Dean, 1982). These data have been used in several attempts to define the geological significance of the Cambrian-Ordovician boundary as a eustatic event. Unfortunately, available reports are deficient in that the Cambrian-Tremadocian boundary is frequently miscorrelated into North American sequences while the limited amount of lithological data on boundary sections frequently is misused. Although a eustatic signature is proposed in this report, it differs from previous syntheses in locating the event within the uppermost *Cordylodus proavus* Zone and lower part of Fauna B. In addition, Cambrian-Tremadocian boundary off-lap followed by on-lap reflects changes in relative rate of sea level rise and not an absolute change of sea level. No satisfactory evidence exists for the glacioeustatic events proposed by various authors.

NORTH AMERICAN TREMADOCIAN LOWER BOUNDARY INTERVAL

Broom Point, Western Newfoundland

A significant improvement in the biostratigraphic resolution of the correlation of the lowest Tremadocian followed from the recovery of conodonts in association with early Tremadocian-aspect planktic dendroids at the Broom Point sections, western Newfoundland (Fortey and others, 1982). Landing (*in* Fortey and others, 1982, p. 116) emphasized that conodont faunas associated with the planktic dendroids in these continental slope sequences did not provide an unambigous correlation with the roughly coeval conodont zonation documented on the carbonate platform in the south-central and Cordilleran United States (see Miller and others, 1982). In a sense, the Broom Point conodont fauna is a stratigraphically mixed assemblage that included (1) species known from the upper *Cordylodus proavus* Zone and lower conodont Fauna B interval, (2) species reported to be restricted to the upper *Cordylodus proavus* Zone (=*Hirsutodontus simplex* [Druce and Jones 1971], *H. hirsutus* Miller 1969, and *Clavohamulus elongatus* Miller 1969), and (3) the "diagnostic" lower Fauna B species *Cordylodus lindstromi* Druce and Jones 1971 (see Miller, 1978, 1980; Miller and others, 1982). If reworking and redeposition of conodont elements has not taken place, conodonts associated with early Tremadocian-aspect planktic dendroids at Broom Point may be referred to lower conodont Fauna B based on the presence of *C. lindstromi* with *Iapetognathus preaengensis* Landing 1982 (Landing, *in*, Fortey and others, 1982, p. 116). The latter species is poorly known in North American platform sequences but has its lowest occurrence with *C. lindstromi* and trilobites of the *Symphysurina brevispicata* Subzone on Mount Wilcox, Alberta (Westrop and others, 1981, fig. 18, see "new genus B").

This tentative conodont-based correlation accurately reflects the limits of conodonts in correlation of the Cambrian-Tremadocian boundary interval between faunal provinces and biofacies belts. The preferred correlation of the lowest Tremadocian with the lower Fauna B interval on the platform allows the ranges of *Hirsutodontus simplex*, *H. hirsutus*, and *Clavohamulus elongatus* to continue upward into an interval equivalent to the lower Fauna B interval on the North American platform. Although this interpretation seems to flaunt the "traditional wisdom" and Miller (1984, p. 54) referred the Broom Point faunas to the older *Hirsutodontus simplex* Subzone without discussion, it should be emphasized that diverse conodont faunas from the upper *Cordylodus proavus* Zone through the lower Fauna B interval are documented from the middle carbonate platform at only three lithofacially similar western United States sections (Miller and others, 1982). The persistence of these three species into a lower Fauna B-equivalent interval in the environmentally distinct and geographically distant marginal facies at Broom Point requires no great leap of faith. Indeed, Miller and others (1982, figs. 5,6) show these species ranging to the very top of the local *Cordylodus proavus* Zone in carbonate platform sections in Oklahoma and Texas. The local ranges of these species of *Hirsutodontus* and *Clavohamulus* can hardly be expected to document the complete biostratigraphic interval in which they may occur because of present geographic and paleoenvironmental limitations in sampling.

Coeval conodont sequences from several other North American regions do not help to resolve this seeming problem of relative diachroneity of occurrence of conodont species at Broom Point. Many key genera and species relied on for the subzonation of the *Proconodontus* and *Cordylodus proavus* Zones were either not recovered or are extremely rare in sections of the Rabbitkettle Formation (deep carbonate shelf) at Broken Skull Pass, District of Mackenzie (Landing and others, 1980); the Mistaya and Survey Peak Formations (outer carbonate and detrital belts, respectively), Mount Wilcox, Alberta (Westrop and others, 1981); the Gorge and Highgate Formations (proximal continental slope), northwestern Vermont (Landing, 1979, 1983); and Hatch Hill Formation (middle-lower continental slope), Taconic allochthon, eastern New York (Landing, 1979). The strong lithofacies association of many Cambrian-Ordovician boundary conodonts is particularly evident in the *Cordylodus proavus* Zone of the lower Survey Peak Formation where the extremely abundant conodont collections on Mount Wilcox include only a few specimens of *Hirsutodontus* and lack *Fryxellodontus* and *Clavohamulus* (Westrop and others, 1981). The necessary conclusion is that conodonts allow a finely resolved and reproducible subzonation of the Cambrian-Ordovician boundary interval in the shallow subtidal, middle carbonate platform. However, this subzonation is not fully appropriate even in other North American lithofacies belts. This conclusion is buttressed by work in the *Cordylodus proavus* Zone at section cc in the Rabittkettle Formation, District of Mackenzie (see Ludvigsen and Westrop, 1983), and the lower part of the Grove Formation, eastern Maryland. Again, conodont faunas from these outer carbonate ramp and high energy platform margin sequences, respectively, lack *Fryxellodontus*, *Hirsutodontus* and *Clavohamulus* (Landing, unpub. data).

The Broom Point sections demonstrate the association and suggest a correlation of the local immigration event of early Tremadocian-aspect planktic dendroids with a lower Fauna B-aspect conodont fauna. Unfortunately, a major unconformity is marked at Broom Point South by debris aprons (conglomerates B3 and B2) that contain platform margin blocks with trilobites. Strata equivalent, at least, to all of the *Cordylodus proavus* Zone seem to be missing (Landing, *in* Fortey and others, 1982, p. 115), and information from other sections is required to demonstrate whether the earliest part of the panktic dendroid immigration event is represented at Broom Point.

Cap des Rosiers, Quebec

Rasetti (1954) described the trilobites *Pareuloma* and *Borthaspidella* from a sea cliff section in the Cap des Rosiers Group in easternmost Gaspe. Bedded quartzose echinoderm packstones and dark shales at the locality represent amalgamated grain flows and turbiditic deposits deposited on the continental slope. These trilobites and a very abundant rooted *Dictyonema* fauna were collected 5.1 m and 6.2 m, respectively, above the base of the section (Landing and others, 1986). Associated conodonts (including *Cordylodus lindstromi*, *C. intermedius* Furnish 1938 s.l. [elements with a less convex margin than the illustrated type; see Landing, 1983, fig. 7H], *C. drucei* Miller 1980, and *Iapetognathus preaengensis*) are comparable to the Fauna B-aspect assemblage at Broom Point. The graptolite fauna may be older than the local immigration event(s) of early Tremadocian planktic dendroids elsewhere or may represent an environment that restricted the local appearance of planktics.

Columbia County, New York

Continental slope shales, bedded lime mudstones, calcareous quartz arenites, and thin debris aprons are exposed in a road cut on U.S. Route 9-23 to the southeast of the City of Hudson, New York (see Friedman, 1979). Macrofossils from this exposure in the upper part of the Hatch Hill Formation include the trilobite *Clelandia* (at 5.8 m), abundant rooted dendroids (11.6 m), and planktic *Dictyonema* and rooted dendroids (13.3 m). A relatively uniform conodont fauna, including the same species at Cap des Rosiers (listed above) with *Utahconus utahensis* (Miller 1969) occurs throughout the section (21.6 m) (Landing, 1979; unpub. data). A lower conodont Fauna B-aspect assemblage precedes and is associated with the local immigration of early Tremadocian-aspect planktic dendroids in this section in the Taconic allochthon, eastern New York.

Naersnes, Norway

Recent work on the "Naersnes type section" and "Naersnes beach section" (see Bruton and others, 1982) allows for conodont-based correlations of uppermost Cambrian and lowest Tremadocian trilobites and planktic dendroids in the Baltoscandian black shale facies.

The association of *Utahconus utahensis* and a *Semiacontiodus* similar to *S. nogamii* (Miller 1969) with somewhat longer ranging conodonts in the *Acerocare ecorne*-bearing nodule (D.L. Bruton, oral presentation, Plenary Session of the Working Group on the Cambrian-Ordovician Boundary, Calgary, July, 1985; J.E. Repetski, personal commun., 1985) is comparable to that in the *Hirsutodontus simplex* Subzone through lower Fauna B interval in Texas and Oklahoma (see Miller and others, 1982). Interestingly, *Cordylodus lindstromi*, *C. intermedius* s.l., and *Iapetognathus preaengensis* appear as low as the *Boeckaspis*-bearing nodule and persist as key elements of the fauna into the range of planktic *Dictyonema*.

Dayangcha Area, China

The local appearance of planktic dendroids within the lower part of a lower Fauna B-aspect interval also occurs at the Xiayangqiao section near Dayangcha, China (Chen and others, 1985). An upper *Cordylodus proavus* Zone (=*Hirsutodontus simplex* Subzone-aspect or higher) fauna with *Semiacontiodus nogamii*, *C. intermedius* s.l., *C. drucei*, *Monocostodus sevierensis*, and *Utahconus utahensis* (17 m to 32 m from base of section) is joined by *C. lindstromi* and *U. tenuis* Miller 1980 (32 m) below the local first appearance of early planktic dendroids (ca. 35 m) at Xiayangqiao. This lower Fauna B assemblage accompanies the local range zone of early Tremadocian dendroids (Chen and others, 1985).

Base of the Tremadocian in North America

The Xiayangqiao and Naersnes sections are particularly significant to correlation of the base of the Tremadocian into North American sequences because they demonstrate the lowest occurrence of a *Cordylodus lindstromi*-bearing fauna above a subjacent upper *Cordylodus proavus* Zone-aspect fauna and below the lowest planktic dendroids. Sections at Broom Point, and in Columbia County, New York, illustrate the arrival of planktic dendroids within a stratigraphic interval bearing *C. lindstromi* and *Iapetognathus preaengensis*.

The utility of *Cordylodus lindstromi* and, locally, *Iapetognathus preaengensis* as aids in recognizing the uppermost sub-Tremadocian-equivalent in non-graptolitic platform sequences is suggested by these sections. Although species such as *C. lindstromi* which are extremely widespread and eurytopic in their distribution will have the longest stratigraphic ranges and poorest potential as an aid in correlation, *C. lindstromi* had evolved and immigrated into a number of regions prior to the local immigration of early Tremadocian planktic dendroids. The Xiayangqiao section demonstrates the species' appearance in a shallow platform setting before the Tremadocian. Lithologic description of this section

(Chen and others, 1985) as well as a videocamera documentary of the section presented at the Plenary Session of the Working Group on the Cambrian-Ordovician Boundary (Calgary, July, 1985) suggests many similarities with the inner detrital belt (see Palmer and Halley, 1979). These include lenticular storm beds, flat limestone clast beds, abundant skeletonized benthic organisms, purple and green glauconitic shales and local stromatolite horizons. These is no reason to suggest that *C. lindstromi's* stratigraphic range here should differ significantly from North American marginal and platform settings.

Available data strongly suggest that the base of the Tremadocian, one of three historically justifiable bases of the Ordovician in the classic Avalonian-Baltoscandian biofacies (see Henningsmoen, 1957), is the equivalent of some portion of the lower conodont Fauna B interval (=upper *Symphysurina brevispicata* and lower *Symphysurina bulbosa/woosteri* Subzones in North American platform sequences [Figure 1]).

Stratotype Recommendation

The base of the Ordovician also is the base of the lowest Ordovician series and regionally appropriate stage. This base at a proposed stratotype will be a physical horizon that must be defined by a biostratigraphic signature (see Hancock, 1977) in a section without important unconformities. North American carbonate platform and presently investigated inner detrital belt sequences are inappropriate because of the imprecision involved in recognition of a historically justifiable base of the Ordovician (base of the Tremadocian) in a non-graptolitic sequence. Although the best correlation of the Cambrian-Ordovician boundary appears to be within the lower part of the lower Fauna B interval, no significant faunal replacements, immigration events, or extinctions affect conodonts or trilobites within this interval in North American Platform sequences.

Selection of a horizon in North American platform sequences as a base of the Ordovician is inappropriate for biostratigraphic work. Such a horizon, even though well defined and recognizable on the platform, is not appropriate because it would be significantly older than the traditional base(s) of the Tremadocian. More importantly, such a horizon would not be widely correlative if based on conodonts or trilobites of the *Cordylodus proavus* Zone. For example, Miller (1984, p. 48) proposed that the demonstrably sub-Tremadocian *Hirsutodontus*

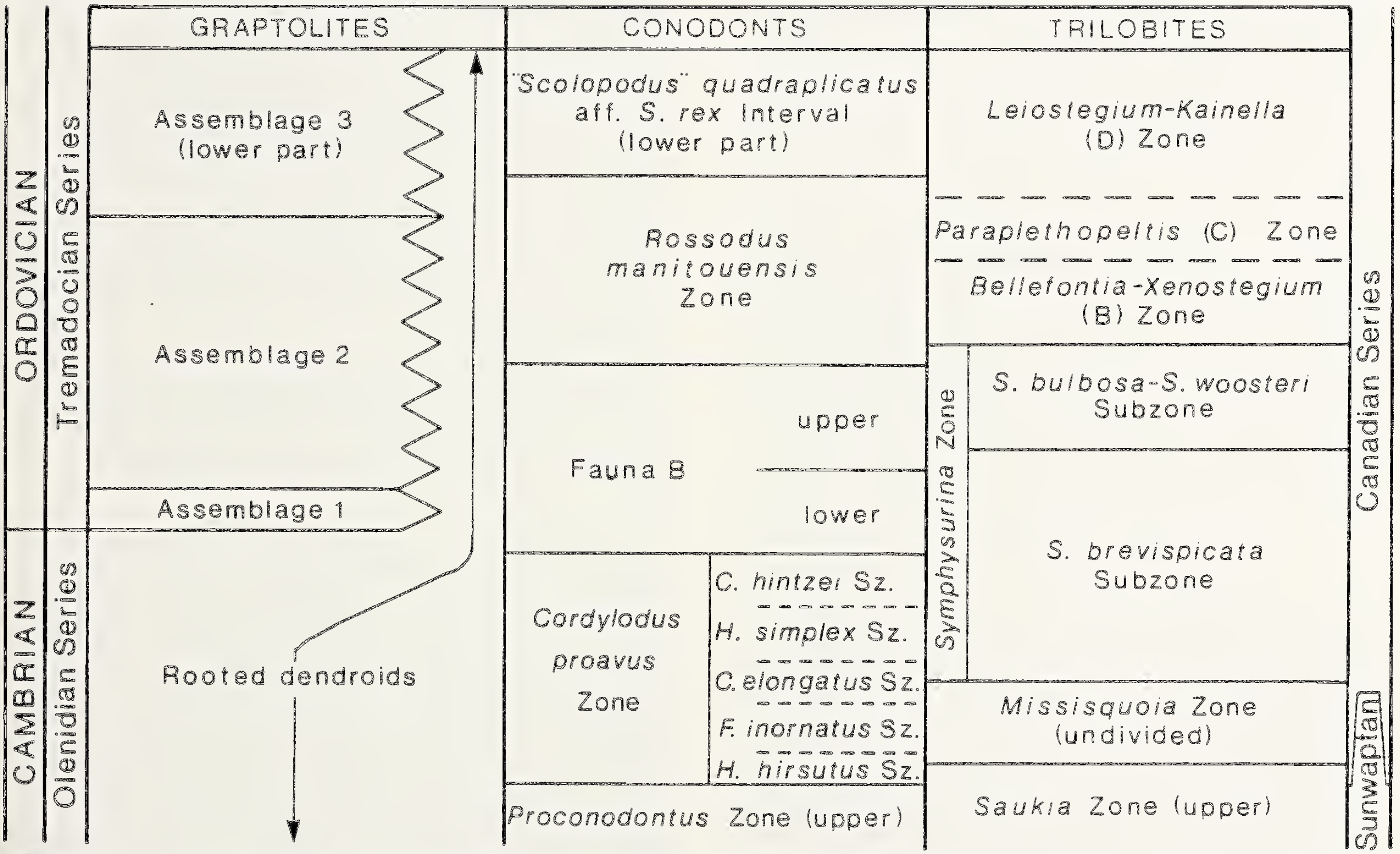


Figure 1 **Correlation of the Cambrian-Ordovician (Olenidian-Tremadocian Series) boundary between marginal/open oceanic settings (graptolites) and North American platform (conodonts and trilobites) faunal sequences (see Landing, 1983; Landing and others, 1986, for further discussion of proposed correlations).**

simplex Subzone was the "base" of the Ordovician. Unfortunately, subzonation of the *Cordylodus proavus* Zone is based largely on species of stenotopic genera (Landing, 1979, 1983; Landing and others, 1980; Miller, 1980, 1984) that are closely circumscribed in their geographic distribution even in North America (discussed above).

The lowest occurrence of lower Fauna B seems to provide the best datum for recognition of the Cambrian-Ordovician (Cambrian-Tremadocian) boundary interval in North America. However, the use of the lowest occurrence of *Cordylodus lindstromi* as a horizon for marking the base of the Ordovician is unacceptable because the origin and range of a species must be somewhat and may be significantly diachronous due to factors controlling its dispersal, competitive exclusion by its ancestor or sister species in local sequences, and environmental barriers to local appearance (see Eldridge, 1972).

Although probable ancestor-descendant or sister taxa relationships will eventually be understood following evaluation of *Cordylodus lindstromi* and other geographically widespread cordylodan species, use of these phylogenies cannot be applied as a logical or practical standard for correlation of the Cambrian-Ordovician boundary (see Eldridge and Gould, 1977). The simplest, most practical and most satisfying standard for correlation of the Cambrian-Ordovician boundary and its definition at a stratotype derives from the traditional principle of overlapping range zones (Berry, 1968). This situation is present at the Xiayangqiao and the stratigraphically incomplete Broom Point sections where a *Cordylodus lindstromi*-bearing fauna overlaps the lowest horizon of a planktic dendroid fauna with early subspecies of *Dictyonema flabelliforme*. The designation of such a horizon at a stratotype section would preserve the traditional biostratigraphic practice for definition of the base of the Tremadocian Series and Ordovician System in siliciclastic-dominated sequences of Avalonia, Baltoscandia, Amorica, and "Perigondwana." In these regions, the development of a more rigorous and uniform systematics for early planktic dendroids might serve to test whether appreciable diachroneity exists in the local appearance of earliest Tremadocian dendroids. Such a stratotype horizon would be appropriate in conodont-based correlations into carbonate platform sequences because it would serve to restrict the base of the Ordovician into the lower part of a lower Fauna B interval. Unfortunately, biostratigraphic imprecision must be expected in certain lithofacies belts during a geological interval with highly developed biotic provincialism. In any event, carbonate platform biostratigraphy cannot be imposed in the oceanic realm. However, there is commonly little problem differentiating sub-Tremadocian-equivalents from Tremadocian-equivalents on the North American platform; the systemic boundary frequently is an unconformity.

SUB-TREMADOCIAN UNCONFORMITIES

Europe and Africa

Tremadocian sediments have long been recognized to be the result of a cumulative on-lap on the Baltoscandian Platform (see Westergaard, 1909). Jaanusson (1979, p. A138-139) noted the widespread sub-Tremadocian unconformity in Baltoscandia as probable evidence of a long-term eustatic transgression but said nothing about when or how many preceding eustatic events may have preceded it. In many regions, the magnitude of the sub-Tremadocian hiatus is so long (e.g., Tremadocian on older units of any age down to Proterozoic) that relevant data representing the time immediately prior to the Tremadocian on-lap are unavailable. Similarly, the Tremadocian commonly overlies Middle Cambrian units in southern Europe and northern Africa (Destombes, 1963; Sdzuy, 1972) and no information is available on the Upper Cambrian.

Henningsmoen (1957) envisioned a general Baltoscandian off-lap in the Late Cambrian because continuous uppermost Cambrian through lowermost Tremadocian sequences are restricted to the Oslo-Bornholm axis. A comparable Late Cambrian off-lap is not obvious in the literature on Wales and central England. Allen and others (1981) document a "comparatively complete" sequence in North Wales while Erdtmann (1982, pp. 19-20) shows an unconformity at the base of many sections. Unfortunately, the primary sources that are cited by Erdtmann (1982) as documenting a sub-Tremadocian unconformity in Avalonian Britain (e.g. Bulman, 1927; Bulman and Rushton, 1973) do not even mention Tremadocian contacts.

The available literature on northwestern Europe is not adequate to evaluate interpretative scenarios of a "small scale eustatic drop" prior to Tremadocian on-lap (see Erdtmann and Miller, 1981; Erdtmann, 1982).

North America

As in Europe and northern Africa, North American cratonic sequences frequently show on-lap of Tremadocian-equivalent units across considerably older sequences. Recent improvements in conodont-graptolite correlation (Landing and others, 1986) indicate that the basal unit above the unconformity frequently is an early-middle Tremadocian-equivalent because upper Fauna B or Fauna C conodonts (or coeval trilobites) are known above the unconformity. Selected examples of this on-lap relationship include the following:

(1) Ooyagah-Cape Clay formational contact, southern Devon Island; upper Fauna B or, more likely, Fauna C

interval on Middle Cambrian (Landing and Barnes, 1980)

(2) Peerless-Manitou formational contact, Colorado Springs area, Colorado; *Bellefontia-Xenostegium* (B) Zone over Upper Cambrian (Sunwaptan Stage) *Ptychaspis*-bearing strata (Berg and Ross, 1959)

(3) type Sunset Point Member (='Madison Sandstone")-Oneota Dolostone contact, Madison, Wisconsin; probable Fauna C interval over Upper Cambrian (Sunwaptan Stage) *Saukia* Zone (Wanenmacher and others, 1934; see Furnish, 1938)

(4) Grenvillian basement-Winchell Creek Siltstone contact, Glens Falls, New York; upper Fauna B or Fauna C on Proterozoic (Fisher and Mazzulo, 1976; Landing, unpub. data).

The sub-Tremadocian disconformity represents a hiatus of shorter duration in several regions. In these areas, on-lap of Tremadocian-equivalents takes place across the eroded upper portion of the Upper Cambrian *Cordylodus proavus* Zone.

The base of the Garden City Formation, northern Bear River Range, northern Utah-southeastern Idaho, is a diachronous disconformity with upper Fauna B- or Fauna C-bearing sandy dolostones immediately overlying the St. Charles Formation (=*Clavohamulus elongatus* Subzone, or somewhat higher, at top; see Landing, 1981; Taylor and Landing, 1982). This same disconformity has been recognized on Stansbury Island and the northern Stansbury Range, northwestern Utah, where it is bracketed by the *Clavohamulus hintzei* Subzone at the top of the St. Charles Formation and upper Fauna B of the lowermost Garden City Formation (Taylor and Repetski, 1985). On the opposite side of North America, intitial deposition of the Tribes Hill Formation (Fauna C interval) took place on an erosional surface developed on the Little Falls Dolostone (=*Clavohamulus elongatus* Subzone) in eastern New York (Brown and others, 1984).

Earlier portions of the early Tremadocian on-lap may be preserved in five widely separated areas. Kurtz (1981) described a section in central Missouri where nonfossiliferous quartz arenites (Gunter Member) overlie the upper Eminence Dolostone (middle part of the *Cordylodus proavus* Zone) at a probable disconformity. Conodonts from the immediately overlying carbonates of the Gasconade Dolostone include lower Fauna B through higher Fauna C assemblages. The relationships suggest, but do not prove, a cut-out of the upper *Cordylodus proavus* Zone and, possibly, the lowest part of Fauna B at the base of the Gunter Member.

Preservation of earliest Tremadocian on-lap sediments may be indicated in Carter Canyon, southern Lakeside Mountains, northwestern Utah, where Taylor and Repetski (1985) reported an Upper Cambrian (Sunwaptan Stage) *Proconodontus* Zone fauna from the uppermost St. Charles Dolostone; overlying "undifferentiated" uppermost *Cordylodus proavus* Zone or lower Fauna B conodonts occur approximately 16 m higher in the Garden City. These authors suggested two unconformities in the section: one at the formational contact and one between the faunas recovered in the Garden City because of the short stratigraphic interval (16 m) that separate them. An alternative interpretation is that this western outcrop of the lowermost Garden City Formation actually records on-lap during early Fauna B "time" across the eroded dolostones of the St. Charles and a stratigraphically condensed interval in the lower Garden City.

Preliminary conodont data allow an admittedly speculative interpretation of a record of earliest Tremadocian on-lap on the western side of the Wisconsin Arch. As noted above, the contact of the Sunset Point member with the overlying Oneota Dolostone seems to mark a significant sub-Tremadocian unconformity on the Wisconsin Arch. However, thin siliciclastics such as the Blue Earth Siltstone and "Kasota Sandstone" underlie the Oneota Dolostone in the Minnesota River Valley and have an Oneota-aspect macrofauna (Stauffer, 1925; Powell, 1935). Sands of the latter type can be lithically similar to those in the Sunset Point and Van Oser Members (*Saukia* Zone) of the Jordan Formation. Miller and Melby's (1971) illustration of a *Cordylodus lindstromi* element with characteristic secondary basal tips (identified as *Cyrtoniodus prion* s.f.) and other conodonts that may also represent lower Fauna B from sections assigned to the Sunset Point and even the Van Oser Member (see Stauffer, 1940) indicates that the stratigraphy of the Trempealeau Group still is not fully worked out. These conodonts come from sandstones in western Wisconsin and adjacent Minnesota that may prove to be Kasota and Gunter equivalents deposited during early Tremadocian on-lap. The Cambrian-Ordovician (Cambrian-Tremadocian-equivalent) boundary in the upper Mississippi River Valley may prove to be a significant disconformity within the type region of the Trempealeauan "Stage" (compare Witze, 1985, p. 664).

Hubei Province, China

A disconformity marking the early, but not earliest, Tremadocian on-lap is present in a section at Huanghuachang village in the lower Yangtze gorge. Ni and others (1984; Chen and others, 1984) recovered *Hirsutodontus simplex* Subzone or somewhat younger conodonts from the uppermost Xilingxia Formation and a characteristic Fauna C assemblage at the base of the overlying Nanjinguan Formation. The magnitude of the stratigraphic break and even the presence of limestones over a strongly dolomitized underlying unit is remarkably similar to the St. Charles-Garden City and Little Falls-Tribes Hill relationships described above.

DISCUSSION

Cambrian-Tremadocian Boundary Correlation

The necessary correlation of the Cambrian-Ordovician (Cambrian-Tremadocian) boundary at a level within the lower conodont Fauna B interval aids in construction of a coherent temporal framework that helps relate the stratigraphic developments of a number of North American sequences. Over the last decade, successive reports have served to place the Cambrian-Tremadocian boundary at progressively higher levels in North American sequences (see Landing and others, 1978; Landing, *in* Fortey and others, 1982; Miller, 1984). This report accepts Chen and other's (1985) correlation of earliest Tremadocian dendroids. Recent attempts to correlate the base of the Tremadocian into significantly older strata, such as at the base or within the *Cordylodus proavus* Zone (Apollonov and others, 1981; Chugaeva and Apollonov, 1982; Barnes, 1984; Fortey, 1984; Miller, 1984) distort this history.

Sub-Tremadocian Unconformity

Recognition of the base of the Ordovician is not problematical in many North American platform sequences because it lies at a disconformity (often interformational) that frequently is below the lowest occurrence of upper Fauna B or Fauna C conodonts. This disconformity intervenes as a regional break within Palmer's (1981) "Sauk III Subsequence" in Utah, southern Idaho, the upper Mississippi River Valley, New York, Colorado, and Devon Island. A sub-Tremadocian break on the North American, Baltoscandian, Amorican, Gondwana, and east China platforms indicates a eustatic control of cumulative Tremadocian on-lap. Evidence for this on-lap is, unfortunately, not persuasive in Avalonian Platform sequences. Onset of this on-lap seems to be bracketed by the uppermost *Cordylodus proavus* Zone and the lower part of the lower Fauna B interval in central Missouri and Queensland, Australia (discussed below). Similarly, strata with lower Fauna B conodonts on the western side of the Wisconsin Arch and, questionably, in the southern Lakeside Mountains, Utah, may be initial deposits of the on-lap.

Eustatic Model

It should be emphasized that none of the evidence demonstrates a "small scale eustatic drop" just prior to the Tremadocian (Erdtmann and Miller, 1981) followed by an extremely rapid glacioeustatic rise (Erdtmann, 1982). Despite the several repetitions of this thesis (Miller, 1978; Miller and others, 1977), no Cambrian-Ordovician boundary sequence requires an absolute fall and subsequent rise in sea level to explain stratigraphic developments. Rather, the details of all sequences are consistent with a model featuring relative fall of sea level at least through the uppermost Cambrian (middle or upper *Cordylodus proavus* Zone) and restriction of shallow marine accumulation to regions of the marginal and middle platform. The effect of a relative fall in sea level may be reflected by the appearance within the *Missisquoia* Zone of the peritidal facies characterizing the House Limestone in west-central Utah (see Cook and Taylor, 1977). Subsequently, a (further) decrease in the relative rate of sea level rise (see Pitman, 1978) in these facies belts would have multiple consequences. These would include emergence and production of disconformities and more restricted marine lithofacies in less rapidly subsiding (commonly shoreward) areas, aggradation and appearance of higher energy deposits such as those noted by Miller (1984) in the *Hirsutodontus simplex* interval, and progradation of unstable platform margins that could collapse to produce sub-Tremadocian debris aprons (such as those at Broom Point, western Newfoundland [Fortey and others, 1982] and bed 23 at Highgate gorge, northwestern Vermont [Landing, 1983]).

Restricted marine conditions reflecting the relative decrease in rate of sea level rise in the boundary interval are evident in several regions. A facies characterized by flat limestone clast conglomerates and interpreted as the product of hypersaline and the shallowest environments of the Ninmaroo Formation (see Radke, 1978), appears prior to and extends into the lower Fauna B interval in Queensland, Australia (Druce and others, 1982). This facies, known as the Mort Member, appears to mark the pre-Tremadocian decrease in relative rate of sea level rise. The overlying Corrie Member, characterized by more normal marine facies of Radke's (1978) "skeletal" and "mixed carbonate" limestones, would seem to represent a unit deposited later (upper part of lower Fauna B through Fauna C) during the cumulative Tremadocian on-lap. Miller's (1984) "Black Mountain Eustatic Event" (BMEE) seems to be interpreted as a relatively abrupt sea level fall and rise couplet within the relatively normal marine facies of the Corrie Member. The evidence cited for the "BMEE" is not particularly persuasive based on Miller's (1984) discussion of its "type" locality in the Black Mountain section. Miller's (1984) proposal of the "BMEE" seems to be based on shallow-water features in the lower Corrie Member and the presence of "karst" features. Comparable features characterize the underlying Mort Member where reported "karst" features appear to be peritidal hardgrounds (see Radke, 1978). The "BMEE" was regarded as a separate eustatic event from the "sea level low stand" claimed by Miller (1984) within the *Hirsutodontus simplex* Subzone. In doing this, that author appears to have created a situation similar to that caused by Cooper

(1977) where the actual number of Cretaceous eustatic events is multiplied. This situation arises when the somewhat diachronous ages of initial on-lap sediments at a number of localities are interpreted as the products of separate eustatic events rather than as the result of cumulative on-lap either across low angle unconformity surfaces or into areas of continuous deposition but with differing epeirogenic behavior. In any case, the fact that the "BMEE" is placed in the lower-upper Fauna B transition interval means that it cannot be regarded as marking the middle-upper Tremadocian boundary (*fide* Miller, 1984). Recent conodont-graptolite correlations would place the "BMEE" in the early Tremadocian (Figure 1; Landing and others, 1986).

Two Arctic Ocean regions show a change from restricted to more open shelf deposition in the Fauna B interval and have a general stratigraphic similarity to the Ninmaroo Formation in Queensland. Miller (1978, p. 17) noted that Fauna B assemblages were recovered from the Cass Fjord Formation, western North Greenland, from limestones "somewhat above a sandy and evaporitic interval." Nowlan (1985) examined strata tentatively assigned to the Cass Fjord Formation on northwestern Devon Island and noted (Nowlan, 1976) that the transition from "Member 2" to "Member 3" involved the passage from intertidal and supratidal into subtidal facies. Nowlan's (1976, 1985) conodont data are relatively limited but on-lap in North Greenland and northwestern Devon Island may prove to be approximately coeval. The restricted marine conditions in both regions began in the Upper Cambrian (*Proconodontus* Zone) and signify nothing, at least at present, about pre-Tremadocian eustasy.

Subsequent Tremadocian on-lap seems to have been far less dramatic than the abrupt glacioeustatic event (Miller and others, 1977; Miller, 1978; Erdtmann and Miller, 1981) featuring the abrupt rise of "cold," "anoxic," "continental slope" water as envisioned by Erdtmann (1982). It is significant that no dramatic shifts in lithofacies belts or exotic lithologies occur in relatively continuous platform sequences. Most units, such as the House Limestone, retain a peritidal or shallow sub-tidal aspect due to roughly equivalent rates of submergence and accumulation during the Temadocian on-lap. There is only one known area where the rate of cumulative early Tremadocian sea level rise may have exceeded the long-term accumulation rate. The transition from the Basal Silty Member into the Putty Shale Member of the Survey Peak Formation in western Alberta (see Aitken and Norford, 1967) features a textural fining and loss of prominent tempestites. This transition takes place a few meters above the joint lowest occurrence of *Jujuyaspis*, *Cordylodus lindstromi* and *Iapetognathus preaengensis* (Westrop and others, 1981). Cumulative deepening may be present in the similar facies of the Deadwood Formation in the Williston Basin. However, published lithologic data does not presently allow such an interpretation (see Lochman, 1964a, 1964b).

In general, the impression is one of a relatively slow cumulative on-lap of North America in the early Tremadocian. The variable ages indicated by conodont faunas above the sub-Tremadocian unconformity (lower Fauna B to Fauna C) suggests a gradual inundation of the Upper Cambrian (lowermost Fauna B interval and older) coastal plain.

Models that propose rapid and profound submergence during the Tremadocian on-lap (Erdtmann and Miller, 1981; Erdtmann, 1982) seem to be in error because their assumed rates of submergence are not reflected in boundary-interval lithofacies packages or in on-lap rates across North America. A second problem with this model is that it attempts to explain black shale deposition during early Tremadocian on-lap of Baltoscandia by an intense sea level rise that brings slope water onto that continental mass. The model assumes a "modern type" of ocean with an anoxic or dysaerobic layer at a relatively great depth on the upper slope. However, it is much more likely that the world ocean from the late Middle Cambrian through middle Tremadocian had a greatly thickened and intensified dysaerobic to anoxic water mass. Well oxygenated facies with an abundant and diverse skeletonized fauna are seemingly absent in deeper water settings in this time interval (Landing and others, submitted). A preferred model is that a relatively minor cumulative sea level rise served to bring dysaerobic water across Baltoscandia with the initial Tremadocian on-lap. Although aggradation on the carbonate platforms allowed for the maintenance of shallow subtidal to peritidal environments during the Tremadocian on-lap, the absence of a "carbonate factory" on the presumably cooler siliciclastic-dominated continents and limited coarse-grained clastic sources allowed regions such as Baltoscandia to undergo relatively rapid submergence during on-lap.

The pervasiveness of dark-colored, fauna-poor, deeper marine facies in the Late Cambrian and early Tremadocian suggests limited circulation and overturn of bottom waters during an interval of relatively subdued latitudinal gradients in climate (see Fischer and Arthur, 1977; Demaison and Moore, 1980). Indeed, the absence of demonstrated and reliably dated glaciomarine sediments or tillites in the Late Cambrian and Early Ordovician (Hambrey and Harland, 1981) helps to explain the apparent poor oxygenation of the world ocean and casts great doubts on the existence of polar continents (compare Erdtmann, 1982, fig. 2) and on glacioeustatic models for sea level change in the Cambrian-Ordovician boundary interval.

ACKNOWLEDGMENTS

Work on the Cap des Rosiers, New York, and Maryland sequences mentioned in the text was done during the tenure of NSF grant EAR-76-10601 (F.H.T. Rhodes, Principal Investigator). D.L. Bruton and J.E. Repetski are thanked for the generosity shown in sharing information on the Naersnes sections.

REFERENCES CITED

Aitken, J.D. and Norford, B.S. 1967. Lower Ordovician Survey Peak and Outram formations, southern Rocky Mountains of Alberta. Bull. Can. Petrol. Geol. 15:150-207.

Allen, P.M., Jackson, A.A., and Rushton, A.W.A. 1981. The stratigraphy of the Mawddach Group in the Cambrian succession of North Wales. Proc. Yorkshire Geol. Soc. 43:295-329.

Apollonov, M.K., Chugaeva, M.N., and Dubinina, S.V. 1981. The Cambrian-Ordovician boundary in the Mali Karatau Range, south Kazakhstan. *In* Taylor, M.E. (ed.), Short Papers for the Second International Symposium on the Cambrian System 1981. U.S. Geol. Surv. Open-File Rept. 81-743, pp. 15-17.

Barnes, C.R. 1984. Early Ordovician eustatic events in Canada. *In* Bruton, D.L. (ed.), Aspects of the Ordovician System. Palaeont. Cont. Univ. Oslo No. 295, pp. 51-64.

Bassett, M.G. and Dean, W.T. (eds.). 1982. The Cambrian-Ordovician Boundary: Sections, Fossil Distributions, and Correlations. Natl. Mus. Wales. Geol. Ser. 3, 227 p.

Berg, R.R. and Ross, R.J., Jr. 1959. Trilobites from the Peerless and Manitou formations, Colorado. J. Paleont. 33:106-119.

Berry, W.B.N. 1968. Growth of a Prehistoric Time Scale. W.H. Freeman Co., San Francisco, 158 p.

Brown, L.L., Kelly, W.M., and Landing, E. 1984. Magnetic results from carbonate rocks from central New York State: possible remagnetization. Geol. Soc. Amer. Abstracts with Programs 16:4.

Bruton, D.L., Erdtmann, B.D., and Koch, L. 1982. The Naersnes section, Oslo region, Norway: a candidate for the Cambrian-Ordovician boundary stratotype at the base of the Tremadoc Series. *In* Bassett, M.G. and Dean, W.T. (eds.), The Cambrian-Ordovician Boundary: Sections, Fossil Distributions, and Correlations. Natl. Mus. Wales Geol. Ser. 3, pp. 61-69.

Bulman, O.M.B. 1927. A monograph of the British dendroid graptolites, Part 1. Palaeontogr. Soc. Monogr., 28p.

___________ and Rushton, A.W.A. 1973. Tremadoc faunas from boreholes in central England. Bull. Geol. Surv. Gt. Brit. 43:2-40.

Chen Q.-l., Qian Y.-y., Lin Y.-k., Zhang J.-m., Wang Z.-h., Yin L.-m., and Erdtmann, B.-D. 1985. Study on Cambrian-Ordovician boundary strata and its biota in Dayangcha, Hunjiang, Jilin, China. China Prospect Pub. Hous., Beijing, 138 p.

Chugaeva, M.N. and Apollonov, M.K. 1982. The Cambrian-Ordovician boundary in the Batyrbaisai section, Mali Karatu Range, Kazakhstan, USSR. *In* Bassett, M.G. and Dean, W.T., (eds.), The Cambrian-Ordovician Boundary: Sections, Fossil Distributions, and Correlations. Natl. Mus. Wales Geol. Ser. 3, pp. 75-85.

Cook, H.E. and Taylor, M.E. 1977. Comparison of continental slope and shelf environments in the Upper Cambrian and lowest Ordovician of Nevada. *In* Cook, H.E. and Enos, P. (eds.), Deep-water carbonate environments. Soc. Econ. Paleont. Mineral. Spec. Paper 25, pp. 51-81.

Cooper, M.R. 1977. Eustasy during the Cretaceous: its implications and importance. Palaeogeogr. Paleoclim. Palaeoecol. 22:1-60.

Cooper, R.A. 1979. Sequence and correlation of Tremadoc graptolite assemblages. Alcheringa 3:7-19.

Demaison, G.J. and Moore, G.T. 1980. Anoxic environments and oil source bed genesis. Bull. Amer. Assoc. Petrol. Geol. 64:1179-1209.

Destombes, J. 1963. Stratigraphie et paleogeographie de l'Ordovicien de l'Anti-Atlas (Maroc): un essai de synthese. Bull. Soc. Geol. de France 7:453-460.

Druce, E.C. and Jones, P.J. 1971. Cambro-Ordovician conodonts from the Burke River structural belt, Queensland. Austral. Bur. Mineral Res., Bull. 110, 67 p.

___________, Shergold, J.H., and Radke, B.M. 1982. A reassessment of the Cambrian-Ordovician boundary section at Black Mountain, western Queensland, Australia. *In* Bassett, M.B. and Dean, W.T. (eds.), The Cambrian-Ordovician Boundary; Sections, Fossil Distributions, and Correlations. Natl. Mus. Wales Geol. Ser. 3, pp. 193-209.

Eldridge, N. 1972. Systematics and evolution of *Phacops rana* (Green, 1832) and *Phacops iowensis* Delo, 1935 (Trilobita) in the Middle Devonian of North America. Bull. Amer. Mus. Nat. Hist. 47:45-114.

___________ and Gould, S.J. 1977. Evolutionary models and biostratigraphic strategies. *In* Kauffman, E.G. and Hazel, J.E. (eds.), Concepts and Methods of Biostratigraphy. Dowden, Hutchinson and Ross Inc., Stroudsburg, pp. 25-40.

Erdtmann, B.-D. 1982. Palaeogeography and environments of planktic dictyonemid graptolites during the earliest Ordovician. *In* Bassett, M.G. and Dean, W.T. (eds)., The Cambrian-Ordovician Boundary: Sections, Fossil Distributions, and Correlations. Natl. Mus. Wales Geol. Ser. No. 3, pp. 9-27.

__________ 1983. A reorganization and proposed phylogenetic classification of planktic Tremadoc (Early Ordovician) dendroid graptolites. Norsk Geol. Tidsskr. 61:121-144.

__________ and Miller, J.F. 1981. Eustatic control of lithofacies and biofacies changes near the base of the Tremadocian. *In* Taylor, M.E. (ed.), Short papers for the Second International Symposium on the Cambrian System 1981. U.S. Geol. Surv. Open-File Rept. 81-743, pp. 78-81.

Fischer, A.G. and Arthur, M.A. 1977. Secular variations in the marine realm. *In* Cook, H.E. and Enos, P. (eds.), Deep-water carbonate environments. Soc. Econ. Paleont. Mineral. Spec. Pub. 25, pp. 19-50.

Fisher, D.W. and Mazzullo, S.J. 1976. Lower Ordovician (Gasconadian) Great Meadows Formation in eastern New York State. Bull. Geol. Soc. Amer. 57:1443-1448.

Fortey, R.A. 1984. Global earlier Ordovician transgressions and regressions and their biological implications. *In* Bruton, D.L. (ed.), Aspects of the Ordovician System. Palaeont. Cont. Univ. Oslo No. 295, pp. 37-63.

__________, Landing, E., and Skevington, D. 1982. Cambrian-Ordovician boundary sections in the Cow Head Group, western Newfoundland. *In* Bassett, M.G. and Dean. W.T. (eds.), The Cambrian-Ordovician Boundary: Sections, Fossil Distributions, and Correlations. Natl. Mus. Wales Geol. Ser. No. 3, pp. 95-129.

Friedman, G.M. 1979. Sedimentary facies and their products: shelf, slope, and rise of Proto-Atlantic (Iapetus) Ocean, Cambrian and Ordovician Periods, eastern New York. *In* Friedman, G.M. (ed.), New York State Geol. Assoc.-New Engl. Intercoll. Geol. Conf., Troy, pp. 47-86.

Furnish, W.M. 1938. Conodonts from the Prairie du Chien (Lower Ordovician) beds of the upper Mississippi Valley. J. Paleont. 12:318-340.

Hambrey, M.J. and Harland, W.B. 1981. Summary of Earth's pre-Pleistocene glacial record. *In* Hambrey, M. and others (eds.), Earth's pre-Pleistocene glacial record. Cambridge Univ. Press, pp. 943-954.

Hancock, J.M. 1977. The historic development of concepts of biostratigraphic correlation. *In* Kauffman, E.G. and Hazel, J.E. (eds.), Concepts and Methods of Biostratigraphy. Dowden, Hutchinson and Ross Inc., Stroudsburg, pp. 3-22.

Henningsmoen, G. 1957. The trilobite family Olenidae. Skr. Utgitt. Norske Videns.-Akad Oslo No. 1, 303 p.

__________ 1969. Short account of Cambrian and Tremadocian of Acado-Baltic Province. *In* Kay. G.M. (ed.), North Atlantic-Geology and continental drift. Amer. Assoc. Petrol. Geol. Mem. 12, pp. 110-115.

__________ 1973. The Cambro-Ordovician boundary. Lethaia 6:423-439.

Jaanusson, V. 1979. Ordovician. *In* Robison, R.A. and Teichert, C. (eds.), Treatise on Invertebrate Paleontology, Part A, Introduction: Fossilization, (Taphonomy), Biogeography, and Biostratigraphy. Geol. Soc. Amer., pp. A136-A166.

Kurtz, V.E. 1981. The Cambrian-Ordovician boundary in Missouri as determined by conodonts. *In* Taylor, M.E. (ed.), Short papers for the Second International Symposium on the Cambrian System. U.S. Geol. Surv. Open-File Rept. 81-743, pp. 115-117.

Landing, E. 1979. Studies in Late Cambrian-Early Ordovician conodont biostratigraphy and paleoecology, northern Appalachian region. Doctoral dissertation, Univ. Michigan, Ann Arbor, 308 p.

__________ 1981. Conodont biostratigraphy and thermal coloration indices of the upper St. Charles and lower Garden City formations. U.S. Geol. Surv. Open-File rept. 81-740, 22 p.

__________ 1983. Highgate gorge: Upper Cambrian and Lower Ordovician continental slope deposition and biostratigraphy, northwestern Vermont. J. Paleont. 57:1149-1187.

__________ and Barnes, C.R. 1980. Conodonts from the Cape Clay Formation (Lower Ordovician), southern Devon Island, Arctic Archipelago. Can. J. Earth Sci. 18:1609-1628.

__________, __________, and Stevens, R.K. 1986. Tempo of earliest Ordovician graptolite faunal succession: conodont-based correlations from the Tremadocian of Quebec. Can. J. Earth Sci. 23:1928-1949.

__________, Benus, A.P., and Whitney, P.R. *Submitted.* Early Ordovician continental slope deposition: macro- and mesoscale shale cycles in the Quebec Reentrant and New York Promontory region.

__________, Ludvigsen, R., and von Bitter, P.H. 1980. Upper Cambrian to Lower Ordovician conodont biostratigraphy and biofacies, Rabbitkettle Formation, District of Mackenzie. Roy. Ontario Mus. Life Sci. Cont. No. 126, 42 p.

__________, Taylor, M.E., and Erdtmann, B.-D. 1978. Correlation of the Cambrian-Ordovician boundary between the Acado-Baltic and North American faunal provinces. Geol. 6:75-78.

Lochman, C. 1964a. Upper Cambrian faunas from the subsurface Deadwood Formation, Williston Basin, Montana. J. Paleont. 38:33-60.

__________ 1964b. Basal Ordovician faunas from the Williston Basin, Montana. J. Paleont. 38:453-476.

Ludvigsen, R. and Westrop, S.R. 1983. Trilobite biofacies of the Cambrian-Ordovician boundary interval in northern North America. Alcheringa 7:301-319.

Miller, J.F. 1969. Conodont fauna of the Notch Peak Limestone (Cambro-Ordovician), House Range, Utah. J. Paleont. 43:413-439.

__________ 1978. Upper Cambrian and lowest Ordovician conodont faunas of the House Range, Utah. *In*

Miller, J.F. (ed.), Upper Cambrian to Middle Ordovician conodont faunas of western Utah. Southwest Missouri State Univ. Geosci. Ser. No. 5, pp. 1-33.

____________ 1980. Taxonomic revisions of some Upper Cambrian and Lower Ordovician conodonts with comments on their evolution. Univ. Kansas Paleont. Cont. Paper 99, 44 p.

____________ 1984. Cambrian and earliest Ordovician conodont evolution, biofacies and provincialism. *In* Clark, D.L. (ed.), Conodont biofacies and provincialism. Geol. Soc. Amer. Spec. Paper 196, pp. 43-68.

____________ and Melby, J. 1971. Trempealeauan conodonts. *In* Clark, D.L. (ed.), Conodonts and biostratigraphy of the Wisconsin Paleozoic. Wisconsin Geol. Nat. Hist. Surv. Circ. 19, pp. 4-9, 78-81.

____________, Stitt, J.H., and Derby, J.R. 1977. Faunal and lithofacies changes across the North American Cambrian-Ordovician boundary and their international correlation. Program and Abstracts, Third International Symposium on the Ordovician System, Columbus, Ohio, pp. 6-7.

____________, Taylor, M.E., Stitt, J.H., Ethington, R.L., Hintze, L.F., and Taylor, J.F. 1982. Potential Cambrian-Ordovician boundary sections in the western United States. *In* Bassett, M.G. and Dean, W.T. (eds.), The Cambrian-Ordovician Boundary: Sections, Fossil Distributions, and Correlations. Natl. Mus. Wales Geol. Ser. No. 3, pp. 155-180.

Ni S.-h., Wang X.-f., Xu G.-h., Zhou T.-m., Zeng Q.-l., Li Z.-h., Xiang L.-w., and Lai C.-g. 1984. Cambrian-Ordovician boundary section at Huanghuachang, Yichang, Hubei, China. Bull. Yichang Inst. Geol. Mineral. 6:79-92.

Nowlan, G.S. 1976. Late Cambrian to Late Ordovician conodont evolution and biostratigraphy of the Franklinian Miogeosyncline, eastern Canadian Arctic Islands. Doctoral dissertation, University of Waterloo, 590 p.

____________ 1985. Late Cambrian and Early Ordovician conodonts from the Franklinian Miogeosyncline, Canadian Arctic Islands. J. Paleont. 59:96-122.

Palmer, A.R. 1981. Subdivision of the Sauk Sequence. *In* Taylor, M.E. (ed.), Short papers for the Second International Symposium on the Cambrian System 1981. U.S. Geol. Surv. Open-File Rept. 81-743, pp. 160-162.

____________ and Halley, R.B. 1979. Physical stratigraphy and trilobite biostratigraphy of the Carrara Formation (Lower and Middle Cambrian) in the southern Great Basin. U.S. Geol. Surv. Prof. Paper 1047, 131 p.

Pitman, W.C., III. 1978. Relationship between eustasy and stratigraphic sequences of passive margins. Bull. Geol. Soc. Amer. 89:1389-1403.

Powell, L.H. 1935. A study of the Ozarkian faunas of southeastern Minnesota. Sci. Mus. St. Paul Inst. Sci. Bull. 1, 80 p.

Radke, B.M. 1978. Carbonate sedimentation in tidal and epeiric environments and diagenetic overprints: the Ninmaroo Formation (Upper Cambrian-Lower Ordovician), central Australia. Doctoral dissertation, Rensselaer Polytechnic Inst., 329 p.

Rasetti, F. 1954. Early Ordovician trilobite faunas from Quebec and Newfoundland. J. Paleont. 28:581-587.

Sdzuy, K. 1972. Das Kambrium der acadobaltischen Faunenprovinz. Gegenwartiger Kenntnisstand un Probleme. Zentralblatt Geol. Palont. 2, 91 p.

Skevington, D. 1966. The lower boundary of the Ordovician System. Norsk Geol. Tidsskr. 46:111-119.

Stauffer, C.R. 1925. The Jordan Sandstone. J. Geol. 33:699-713.

____________ 1940. Fauna of the Van Oser beds. J. Paleont. 14:54-56.

Taylor, M.E. and Landing, E. 1982. Biostratigraphy of the Cambrian-Ordovician transition in the Bear River Range, Utah and Idaho, western United States. *In* Bassett, M.G. and Dean, W.T. (eds.), The Cambrian-Ordovician Boundary: Sections, Fossil Distributions, and Correlations. Natl. Mus. Wales Geol. Ser. No. 3, pp. 181-191.

____________ and Repetski, J.E. 1985. Early Ordovician eustatic sea level changes in northern Utah and southeastern Idaho. *In* Kerns, J.G. and Kearns, R.L., Jr. (eds.), Orogenic patterns and stratigraphy of north-central Utah and southeastern Idaho. Utah Geol. Assoc. Pub. 14, 1985 Field Conf. Guidebook, pp. 3-85.

Wanenmacher, J.M., Twenhofel, W.H., and Raasch, G.O. 1934. The Paleozoic strata of the Baraboo area, Wisconsin. Amer. J. Sci. 28:1-30.

Westergaard, A.H. 1909. Studier ofver Dictyograptusskiffern och dess granslager. Lunds Univ. Arsskr. N. F. Afd. 2 5(3), 79 p.

Westrop, S.R., Landing, E., and Ludvigsen, R. 1981. Upper Cambrian and Lower Ordovician trilobite and conodont biostratigraphy Wilcox Peak, Jasper National Park, Alberta. *In* Taylor, M.E. (ed.), The Cambrian System in the southern Canadian Rocky Mountains, Alberta and British Columbia. Guidebook for Field Trip 2, Second International Symposium on the Cambrian System, U.S. Geol. Surv., Denver, pp. 45-53.

Witze, B.J. 1985. Comment on "Three new Upper Cambrian stages for North America." Geol. 13:663,664.

Odovician Series/Stages, Graptolitic Basinal Facies, Northern Yukon, Canada

Alfred C. Lenz
Department of Geology, University of Western Ontario

ABSTRACT

The use of Victorian Ordovician Series/Stages is advocated for the northern Yukon graptolite sequences. Zone by zone correlation is attainable for the lower part of the sequence, and correlation with the upper part, while not so precise, is better with the Australian than with the British succession.

INTRODUCTION

Ordovician basin-facies strata that comprise part of the Late Cambrian to late Early Devonian basinal package, generally assigned to the Road River Group (Jackson and Lenz, 1962; Fritz, 1985), are widespread throughout the northern Cordillera. They are particularly well developed in the Richardson Mountains, northeastern Yukon. This area was more or less continuously a deep water trough from the Late Cambrian to late Early Devonian (Lenz, 1972). Ordovician strata consist primarily of dark, bedded chert and dark to black shale, as well as minor dark limestone beds, calcareous nodules and thin to massive debris flows and conglomerates. Graptolites, to the near exclusion of all other organisms, are common to abundant in the shales while conodonts may be present in the rare limestones.

Exposures are everywhere excellent in the river valley sections of the Richardson Mountains. The Peel River section, because of its superior exposure and because it has been studied in detail, is chosen as the focus for this review. The Ordovician part of that section is about 450 m thick (Lenz and Pedder, 1972), and is beautifully and almost 100 percent exposed during low water periods. Structural complexities are very few and generally unambiguous, graptolites are abundant throughout the section, and the uppermost boundary of the System has been well studied (Lenz and McCracken, 1982). The lower boundary between the Tremadocian/Lancefieldian and the Cambrian is less well-known.

LITHOFACIES

Basinal facies (graptolite-bearing) rocks of the Richardson Trough and adjacent Blackstone Trough (Figure 1) are distinctive and stand in sharp contrast to those of the platform rocks of the Porcupine Plateau, Mackenzie Platform and Ogilvie Platform. Platformal rocks are typically massive or banded, cream- or greyish-yellow coloured limestone or dolostone that contain a depauperate and exclusively shelly fauna. Contacts between the platformal and basinal facies are rarely seen, and, when exposed, typically are very abrupt with little interfingering of the two facies. Physical correlation between the two magnafacies is nearly impossible, and faunal correlation, while very difficult, might be possible utilizing conodonts. Detailed studies of the conodonts of the near-basin margin carbonates are urgently needed.

BIOGEOGRAPHY

The fact that North American Ordovician gratolites are relatively readily correlated with those of Australasia, China and northeastern Siberia, and that they were probably dwellers of equatorial regions of the Ordovician world is now well-known (see, for example, Skevington, 1974). The differences between the Lower Ordovician faunas of North America and, in particular, the Cordillera (the Pacific Faunal Province) with those of the classic Welsh borderland region (the Atlantic Faunal Province) are pronounced (see Jackson, 1978, for a succinct summary). Correlation of the Lower Ordovician graptolites of the two faunal realms is, consequently, very difficult, and this has lead to many of the heated discussions of the 1960s. It was only following the use of conodont data (see, for example, Bergström and Cooper, 1973; Bergström, 1978) that correlation with Great Britain became more or less clarified and settled.

The northern Yukon graptolite sequences are similar to those elsewhere in North America (see Barnes and others, 1981; Ross and others, 1982; Carter and Tailleur, 1984). However, they are remarkably similar to those of Victoria, Australia (see Cooper, 1979b; Webby and others, 1981). Zone-by-zone correlation is possible with the upper Lancefieldian to the *decoratus* Zone of the Darriwillian (Figure 2). Beginning with the *teretiusculus* Zone (uppermost Darriwillian), however, faunas become more cosmopolitan. The overlying *N. gracilis* Zone is cosmopolitan although its base appears to be diachronous. Correlations of the middle and upper Gisbornian with the Yukon fauna is less precise, but still reasonably good, and certainly more satisfactory than with the standard Caradocian zones of the British Isles. Finally, during the Bolindian/Ashgillian interval, graptolite faunas become relatively cosmopolitan and it is only then that correlation with the British sequence is somewhat more satisfactory than with the Australasian one.

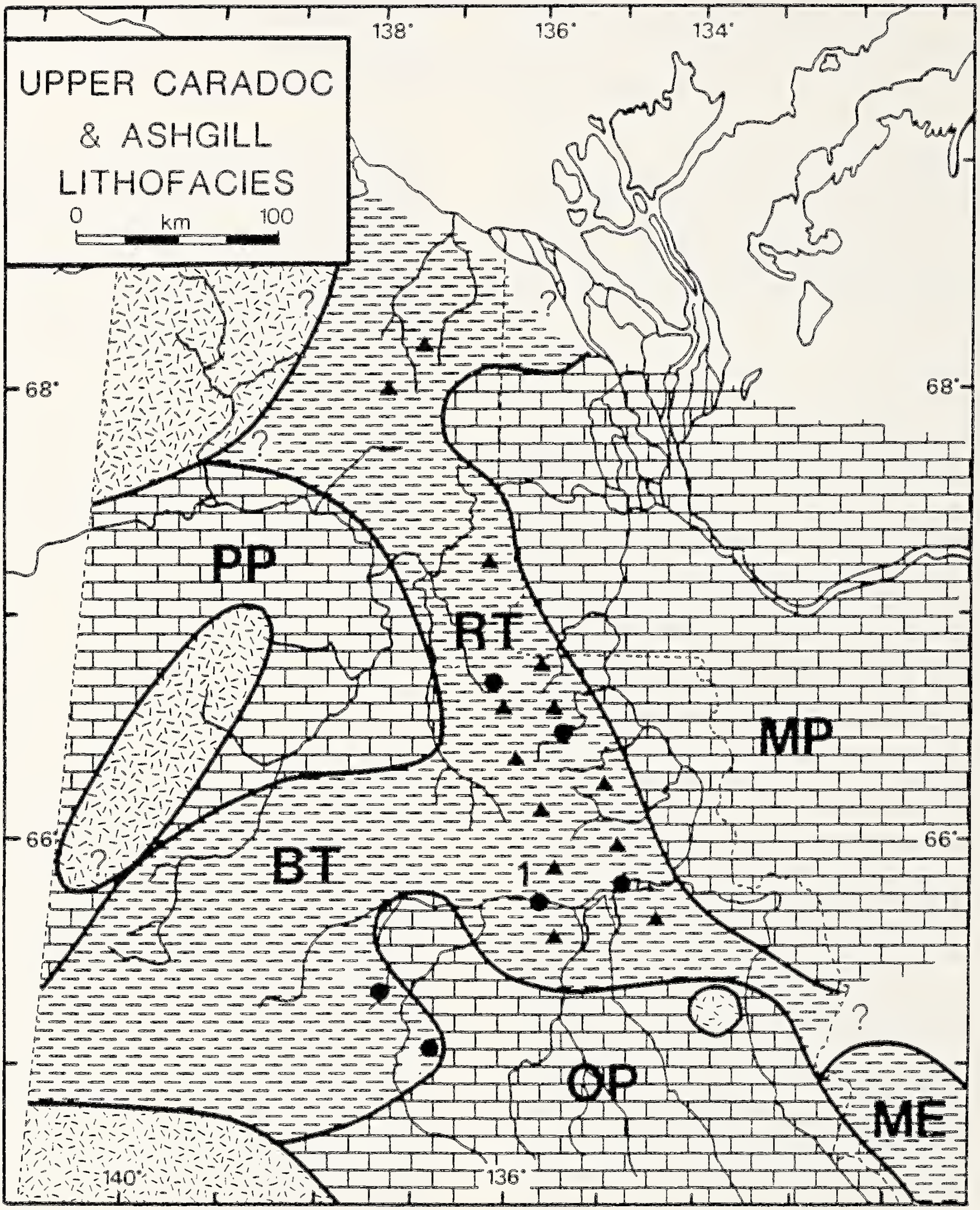


Figure 1 Lithofacies map of northern Yukon. Dashed horizontal lines indicate shale; continuous horizontal lines separated by vertical bars denote platformal carbonates; hatchured areas are positive areas; black triangles are chert; black circles are good graptolite sections, the key section being Peel River indicated by number 1. Tectonic elements are as follows: RT = Richardson Trough; MP = Mackenzie Platform; ME = Misty Creek Embayment; OP = Ogilvie Platform; BT = Blackstone Trough; PP = Porcupine Platform.

It seems clear, therefore, that in view of the strong affinities of the Yukon graptolite faunas with those of Victoria, and, conversely, of the difficulties in correlation with the standard British Ordovician biostratigraphic scheme, the Australasian series/stage must be retained (see also Jackson, 1966). This procedure has been employed and advocated by Carter and Tailleur (1984). The Australasian scheme is used almost exclusively in the following discussion.

BIOSTRATIGRAPHY AND CHRONOSTRATIGRAPHY

Lancefieldian

The lower part of the Lancefieldian, the pre-*approximatus* zones, corresponds to the Tremadocian of the British Isles and is marked by the appearance of a rich fauna of anisograptids and some dichograptids. To date, no *Dictyonema* (sic *Rhabdinopora*) of the *D. flabelliforme*-type has been found in the lower part of the Yukon sequence. Correlation with the Victoria sequence is good (Jackson, 1974, 1975; Cooper, 1979a; Erdtmann and Vandenberg, 1985).

The *T. approximatus* Zone, corresponding to the lowest Arenigian, is very readily recognized by the abrupt appearance of the zonal species and similar forms and includes a diverse fauna of extensiform *Didymograptus* as well as other dichograptids. A few holdover anisograptids, particularly *Clonograptus* and related forms, are still present.

Bendigonian

The appearance of *Tetragraptus fruticosus* and similar types, many species of extensiform *Didymograptus*, as well as asymmetrically branched dichograptids, such as *Goniograptus*, *Sigmagraptus*, and *Trichograptus*, are all characteristic of the Bendigonian. The earliest *Isograptus* appears in this interval. The earlier 3-4 branched, and the younger 3-branched *T. fruticosus*, as recognized by Berry (1960) and Ross and Berry (1963), are not recognizable in northern Yukon (Lenz and Jackson, 1986). Diversity in the interval is high and more than 50 species are present.

Chewtonian

This interval marks the appearance of abundant pendent didymograptids as well as common *Phyllograptus* and the continuation of extensiform didymograptids. The pendent didymograptids, in the past, have been most commonly assigned to *Didymograptus protobifidus*, *D. canadensis* and *D. columbianus*. However, in view of the studies of Williams and Stevens (*In press*), it now appears that all three species are assignable to *D. bifidus* (Hall) s. srt. Diversity remains high, but relatively few species are limited to the interval.

Castlemanian

This series/stage is marked by the appearance of abundant isograptids, including *Isograptus* and *Pseudisograptus*. Diversity is generally only moderately high, but such species as *I. victoriae maximodivergens* are notable for their large size and abundance. Total diversity is lower than for any other interval of the Lower Ordovician and is limited to approximately fifteen species. The

SERIES/ STAGES?	YUKON ZONES	BRITISH SERIES
BOLINDIAN/ ASHGILL	G. perscuptus?	ASHGILL
	? ?	
	P. pacificus	
	D. ornatus	
EASTONIAN	O. quadrimucronatus	CARADOC
	— —?—?— — — —	
GISBORNIAN	D. clingani	
	C. bicornis	
	N. gracilis	LLANDEILO
DARIWILLIAN	G. teretiusculus	
	D. decoratus	LLANVIRN
	P. tentaculatus	ARENIG
YAPEENIAN	Oncograptus	
CASTLEMANIAN	I. victoriae maximodivergens	
	I. victoriae lunatus	
CHEWTONIAN	D. protobifidus	
BENDIGONIAN	T. fruticosus	
LANCEFIELDIAN	T. approximatus	
	A. antiquus	TREMADOC
	C. aureus	
	A. richardsoni	
	S. tenuis	
	? ? ?	

Figure 2 **Comparison and correlation of Victorian Series?/Stages? with Yukon graptolite zones, and with British Series?/ Stages? Reported North American specimens of *Didymograptus protobifidus* have been considered to be representative of *D. bifidus* as known from its middle Arenigian-equivalent type locality at Levis, Quebec (Riva, 1982).**

Castlemanian is divisible into a lower *I. victoriae lunatus* Zone and higher *I. victoriae maximodivergens* Zone. This zonation is based primarily on the occurrence of the nominate species. The same two zones are recognizable in Alaska (Carter and Tailleur, 1984).

Yapeenian

Diversity in this interval is somewhat higher than that of the preceding one. Novelties appearing at this time include *Pseudotrigonograptus ensiformis*, *Skiagraptus*, *Meandrograptus*, and *Apiograptus*. The most distinctive elements of the fauna, *Oncograptus* and *Cardiograptus*, occur in the southern Canadian Cordillera but have not been recovered from northern Yukon (Lenz and Jackson, 1986). Furthermore, the didymograptid and dichograptid elements of the fauna almost disappear in this interval.

Darriwillian

The Dariwillian is characterized by the incoming of an entirely new faunal group that includes the diplograptids. Novelties in the lower division include *Undulugraptus* (e.g., *U. austrodentatus*) and *Climacograptus*, as well as *Paraglossograptus tentaculatus*, *Glossograptus*, *Loganograptus* and the distinctive tylograptids and sinograptids. The middle division, the *D. decoratus* Zone, differs subtly in the appearance of the nominate species, *Amplexograptus*, several species of *Climacograptus* and the lowest occurrence of *G. euglyphus*. Diversity is high in the lower and middle divisions of the Darriwillian.

The upper division, the *G. teretiusculus* Zone, is one of low diversity. It is characterized by the acme of the nominate species along with *G. euglyphus*, the lowest occurrence of *Reteograptus geintzianus*, and the disappearence of almost all of the dichograptids and didymograptids (Lenz and Chen, 1985).

Gisbornian

The first appearance of *Nemagraptus gracilis* is taken as the base of the *N. gracilis* Zone (Lenz and Chen, 1985; Finney, 1985). Taxa that appear in this interval include several species of *Dicellograptus*, as well as those of *Dicrangograptus*, *Azygograptus*, and *Pseudoclimacograptus scharenbergi*. *Leptograptus* and *Corynoides* appear slightly higher in the Peel River section.

The high diversity *N. gracilis* Zone and the overlying *C. bicornis* and *D. clingani*? zones differ only slightly. Each zone is recognized by the first appearance of the eponymous species. The upper limit of the *D. clingani*? Zone is not clear; that is, whether it is confined to the Gisbornian as suggested by Lenz and Chen (1985), or whether, as suggested by conodont studies (McCracken and Lenz, *In press*), it ranges into the overlying lower Eastonian is unclear.

Eastonian

The abrupt change in the faunas between the underlying *D. clingani*? Zone and overlying *O. quadrimucronatus* Zone suggests a faunal break (Lenz and Chen, 1985). Clearly, however, the latter zone is readily correlatable with the upper Eastonian and the uppermost Caradocian. The interval is characterized by the zonal species, *Dicellograptus elegans* and *D.* spp., *Climacograptus tubuliferus*, the first occurrence of *Orthoretiograptus denticulatus* (=*Orthoretiolites pulcherrimus*), and rare *Pleurograptus* spp. (see Williams, 1982b).

Bolindian/Ashgillian

The combination of recent detailed studies on Ashgillian strata of southern Scotland (Williams, 1982a, 1983) and preliminary study of the Bolindian of Australia, allow the ready correlation of the Yukon interval with either the Bolindian or the Ashgillian. Characteristic species appearing at the base include *Dicellograptus ornatus*, *D. minor*, *Glyptograptus altus*, *Climacograptus latus*, *C. hvalross* and *C. hastatus*, moderately common *O. denticulatus* and a profusion of *Orthograptus amplexicaulis* and its subspecies (Lenz and McCracken, 1982; Chen and Lenz, 1984). Higher in section, *Climacograptus supernus* and *Paraorthograptus pacificus* appear in large numbers and constitute the younger *P. pacificus* Zone.

The interval coeval with the *Climacogaptus*? *estraordinarius* Zone of USSR (Koren' and others, 1979) appears everywhere absent in northern Yukon (Lenz and McCracken, 1982).

The highest Ordovician *G.*? *persculptus* Zone is tentatively recognized in some sections in northern Yukon but is missing in the Peel River section. The zone appears to be characterized by the occurrence of thin morphs of *C. normalis* and *C. miserabilis*, as well as a very pilose *Paraorthograptus*? and *Diplograptus modestus*. Further evidence of the existence of the zone is that it underlies the readily and widely recognized earliest Silurian *Parakidograptus acuminatus* Zone.

P. acuminatus Zone

This earliest Silurian zone is recognized at the lowest occurrence of *Parakidograptus acuminatus*, *Climacograptus trifilis*, *Cystograptus vesiculosus* and "*Diplograptus*" *modestus* (see Lenz and McCracken, 1982).

CONCLUSIONS AND RECOMMENDATIONS

(1) The Australasian Ordovician series/stages divisions should be retained as either a biostratigraphic/chronostratigraphic scheme for the (western) North

American graptolite facies or, at the least, be used in parallel with the traditional British scheme.

(2) If the traditional North American three-fold division (ie., Series) of the Ordovician is retained, then the Australasian scheme, would of necessity, be relegated to subseries or stage levels. Because formal subseries divisions have not been proposed for either the Silurian or Devonian Systems, it seems reasonable that the Victorian units become stages. This seems all the more reasonable because a number of the units, for example Bendigonian and Chewtonian, coincide with a single graptolite zone.

REFERENCES CITED

Barnes, C.R., Norford, B.S., and Skevington, D. 1981. The Ordovician System in Canada. Int. Union Geol. Sci. Pub. 8, 27 p.

Bergström, S.M. 1978. Middle and Upper Ordovician conodont and graptolite biostratigraphy of the Marathon, Texas graptolite zone reference standard. Palaeont. 21:723-758.

__________ and Cooper, R.A. 1973. *Didymograptus bifidus* and the trans-Atlantic correlation of the Lower Ordovician. Lethaia 6:313-340.

Berry, W.B.N. 1960. Graptolite faunas of the Marathon region, west Texas. Univ. Texas Pub. 6005, 179 p.

Carter, C. and Tailleur, I.L. 1984. Ordovician graptolites from the Baird Mountains, western Brooks Range, Alaska. J. Paleont. 58:40-57.

Cecile, M.P. and Norford, B.S. 1985. Unrestored Upper Caradocian and Ashgillian facies map. Geol. Surv. Can. Open-File Rept. 1137, 1 p.

Chen X. and Lenz, A.C. 1984. Correlation of Ashgill graptolite faunas central China and Arctic Canada, with a description of *Diceratograptus* cf. *mirus* Mu from Canada. *In* Stratigraphy and Palaeontology of Systemic Boundaries in China. Ordovician-Silurian Boundary (1). Nanjing Inst. Geol. Palaeont., pp. 247-258.

Cooper, R.A. 1979a. Sequence and correlation of Tremadoc graptolite assemblages. Alcheringa 3:7-19.

__________ 1979b. Ordovician geology and graptolite faunas of the Aorangi Mine area, north-west Nelson, New Zealand. Bull. New Zeal. Geol. Surv. 47:1-127.

Erdtmann, B.D. and Vandenberg, A.H.M. 1985. *Araneograptus* gen. nov. and its two species from the late Tremadocian (Lancefieldian, La2) of Victoria. Alcheringa 9:49-63.

Finney, S.C. 1985. Nemagraptid graptolites from the Middle Ordovician Athens Shale, Alabama. J. Paleont. 59:1100-1137.

Fritz, W.H. 1985. The basal contact of the Road River Group – a proposal for its location in the type area and in other selected areas in the northern Canadian Cordillera. Geol. Surv. Can. Paper 85-1B:205-215.

Jackson, D.E. 1966. Graptolitic facies of the Canadian Cordillera and Arctic Archipelago: a review. Bull. Can. Petrol. Geol. 14:469-485.

__________ 1974. Tremadoc graptolites from Yukon Territory, Canada. *In* Rickards, R.B., Jackson, D.E., and Hughes, C.P. (eds.), Special Papers in Palaeontology. Graptolite Studies in Honour of O.M.B. Bulman. Palaeont. Assoc. Spec. Paper 13:35-58.

__________ 1975. New data on Tremadoc graptolites from Yukon, Canada. Palaeont. 18:883-887.

__________ 1978. Recent developments in graptolite research. *In* Stelck, C.R. and Chatterton, B.D.E. (eds.), Western and Arctic Canadian Biostratigraphy. Geol. Assoc. Can. Spec. Paper 18:113-131.

__________ and Lenz, A.C. 1962. Zonation of Ordovician and Silurian graptolites of northern Yukon. Amer. Assoc. Petrol. Geol. Bull. 46:30-45.

Koren', T.N., Soblevskaya, R.F., Mikhajlova, N.F., and Tsai, D.T. 1979. New evidence on graptolite succession across the Ordovician-Silurian boundary in the Asian part of the USSR. Acta Palaeont. Polonica 24:125-136.

Lenz, A.C. 1972. Ordovician to Devonian history of northern Yukon and adjacent District of Mackenzie. Bull. Can. Petrol. Geol. 20:321-361.

__________ and Chen X. 1985. Middle and Upper Ordovician graptolite biostratigraphy of Peel River and other areas of the northern Canadian Cordillera. Can. J. Earth Sci. 22:227-239.

__________ and Jackson, D.E. 1986. Arenig and Llanvirn graptolite biostratigraphy, Canadian Cordillera. *In* Hughes, C.P. and Rickards, R.B., (eds.), Paleoecology and Biostratigraphy of graptolites. Geol. Soc. Special Pub. 20, p. 27-45.

__________ and McCracken, A.D. 1982. The Ordovician-Silurian boundary, northern Canadian Cordillera: graptolite and conodont correlation. Can. J. Earth Sci. 19:1308-1322.

__________ and Pedder, A.E.H. 1972. Lower and Middle Paleozoic sediments and paleontology of Royal Creek and Peel River, Yukon, and Powell Creek, N.W.T. Field Excursion A14, 24th Int. Geol. Cong., Montreal, pp. 1-43.

McCracken, A.D. and Lenz, A.C. 1987. Middle and Late Ordovician conodont faunas and biostratigraphy of graptolite strata of the Road River Group, northern Yukon Territory. Can. J. Earth Sci. 24:643-653.

Riva, J. 1982. The identity of the Lower Ordovician graptolites *Didymograptus bifidus* and *Didymograptus protobifidus* and their biostratigraphic position. Geol. Soc. Amer Abstracts with Programs 14:77.

Ross, R.J., Jr. and Berry, W.B.N. 1963. Ordovician graptolites of the Basin Ranges in California, Nevada, Utah and Idaho. U.S. Geol. Surv. Bull. 1134, 177 p.

____________ and others. 1982. The Ordovician System in the United States. Int. Union Geol. Sci. Pub. 12, 73 p.

Skevington, D. 1974. Controls influencing the composition and distribution of Ordovician graptolite faunal provinces. *In* Rickards, R.B., Jackson, D.E., and Hughes, C.P. (eds.), Special Papers in Palaeontology. Graptolite Studies in Honour of O.M.B. Bulman. Palaeont. Assoc. Spec. Paper 13:59-73.

Webby, B.D. and others. 1981. The Ordovician System in Australia, New Zealand and Antarctica. Int. Union Geol. Sci. Pub. 6, 64 p.

Williams, S.H. 1982a. The Late Ordovician graptolite fauna of the Anceps Bands at Dob's Linn, southern Scotland. Geol. et Palaeont. 16:29-56.

____________ 1982b. Upper Ordovician graptolites from the top Lower Hartfell Shale Formation (*D. clingani* and *P. linearis* zones) near Moffat, southern Scotland. Trans. Roy. Soc. Edinburgh, Earth Sci. 72:229-255.

____________ 1983. The Ordovician-Silurian boundary graptolite fauna of Dob's Linn, southern Scotland. Palaeont. 26:605-639.

____________ and Stevens, R.K. *In press.* Early Ordovician (Arenig) graptolites from the Cow Head Group, western Newfoundland. Paleontogr. Can.

The Myth of a Eustatic Sea Level Drop Near the Base of the Ibexian Series

Rolf Ludvigsen, Brian R. Pratt and Stephen R. Westrop[1]
Department of Geology, University of Toronto

[1] present address: Department of Earth Sciences, Memorial University, St. John's, Newfoundland AlB 3x5

ABSTRACT

A eustatic sea level drop has recently been proposed for the base of the Ibexian Series. The geologic evidence cited includes the appearance of high-energy grainstones in lime mudstone successions, hardgrounds and scoured surfaces in peritidal sequences, debris flows and turbidites in slope sequences, widespread unconformities, and glaciogenic sediments in South America. None of this evidence stands up to critical scrutiny and there is now no reason to suspect that the protracted Lower Ordovician transgression was interrupted by a brief mappable regression.

INTRODUCTION

The Ordovician Period opened with a transgression that has been recognized in cratonic sequences on most continents. It is indicated by the cratonward displacement of off-platform litho- and biofacies and by the spread of marine sediments across continental areas, often with a basal unconformity.

Jaanusson (1979) described the Tremadocian transgression as one of the most extensive in the Paleozoic and, because it was widely recorded, he suggested a eustatic control. Recently, Miller (1984, fig. 1) and Fortey (1984, figs. 3, 4) argued that this widespread and protracted transgression was preceded by a brief eustatic regression with a lithologic and stratigraphic signature that is recognizable on as many as four continents (see also Miller, 1978; Erdtmann and Miller, 1981). Both the regression and its eustatic basis are apparently well on their way toward general acceptance (see, for example, Hallam, 1984, fig. 5, p. 221; Taylor and Repetski, 1985, p. 245). Critical evaluation of the evidence is in order, particularly in view of its possible influence on the imminent decision on the stratigraphic placement and geographic location of the boundary stratotype for the base of the Ordovician System. Here, we show that there is no convincing lithologic or stratigraphic evidence to support the notion of a regressive "hiccup" prior to the Early Ordovician transgression.

The stratigraphic interval considered in this paper includes the upper part of the Sunwaptan Stage and lower Ibexian Series in North America (Ludvigsen and Westrop, 1985) and the upper Merionethian Series and lower Tremadocian Series in Britain (Cowie and others, 1972). The *Dictyonema flabelliforme* Zone at the base of the Tremadocian may correlate with a level close to the base of the *Symphysurina* Zone of the lower Ibexian (Fortey and others, 1982; Figure 1). This is a joint paper and the order of the authorship is alphabetical.

BASAL IBEXIAN REGRESSION

Previous Claims

Miller (1984) claimed to have identified two episodes of eustatic sea level fall in the Early Ordovician. The first episode at the base of the Ibexian Series, named the "Lange Ranch Eustatic Event" (LREE), comprises a pair of brief regressions-one at the coincident bases of the *Cordylodus proavus* (conodont) Zone and the *Eurekia apopsis* (trilobite) Subzone, and the other near the base of the *Missisquoia typicalis* (trilobite) Subzone (Figure 1). The second episode, named the "Black Mountain Eustatic Event," occurs higher in the Ibexian at the first appearance of the conodont *Cordylodus angulatus*. Our remarks are directed at only the basal Ibexian sea level fall (LREE).

Five types of lithologic and stratigraphic evidence have been marshalled in support of the basal Ibexian sea level drop and these are critically evaluated below.

Shallow Water Facies

Miller (1978, 1984, p. 48) suggested that the appearance of high energy, shallow water carbonates in stratigraphic sections in Utah and Texas is evidence for the eustatic sea level drop. The Lava Dam Five section in Utah is typical of the examples cited by Miller. Here, the interval from the upper *Proconodontus* Zone to the lower *Missisquoia typicalis* Subzone in the Notch Peak Formation consists of about a dozen meters of mainly lime mudstone, with a 1-2 m thick unit of oolitic grainstone occurring in the *Eurekia apopsis* Subzone and a 1.0 m thick unit of stromatolitic boundstone and oolitic, intraclastic and bioclastic grainstone occurring in the lower *Missisquoia typicalis* Subzone. Miller must have assumed that externally-controlled water depth was the only factor governing the distribution of these sediments because he claimed that the two grainstone units within the mudstone sequence are direct evidence for the two eustatic sea level drops of the LREE.

Most carbonate sedimentologists do not share Miller's interpretation of such carbonate lithofacies. Local, small-scale lime mudstone-grainstone alternations within very shallow water peritidal sequences can be explained more reasonably as local shifts of related shallow water carbonate environments (Laporte, 1968). Rapid lateral and vertical lithologic transitions, such as those in the Notch Peak Formation, reflect the mosaic-like pattern of environments in shallow epeiric and marginal seas and accretion during gradual sea level rise (Pratt and James, 1986).

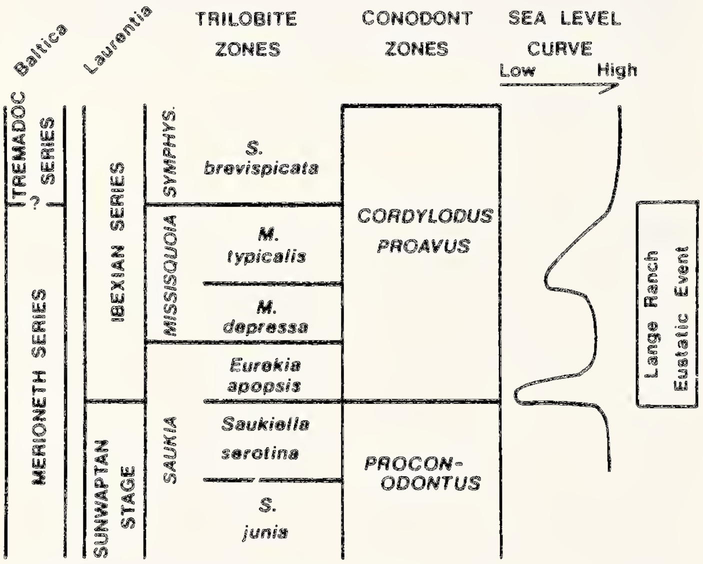


Figure 1 Trilobite and conodont biostratigraphy of the Upper Sunwaptan-lower Ibexian interval in Laurentia, showing Miller's (1984) proposed sea level curve outlining the "Lange Ranch Eustatic Event" (LREE). Correlation with Baltica as suggested by Fortey and others, (1982).

A lateral facies migration model is equally appropriate for the section in Texas discusssed by Miller (1984). He cited the occurrence of lime grainstones and oolites in the lower 20 m of the *Cordylodus proavus* Zone as evidence of regression, but he failed to mention that oolites and limestone pebble conglomerates are common in the underlying 40 m of strata (Miller and others, 1982, text-fig. 5). If Miller's interpretive methods were extended to include the underlying strata, the results would be a plethora of eustatic events which, to use Laporte's (1968, p. 249) words, "would strain geologic credulity."

The assumption that carbonate shallowing-upward cycles are controlled only by eustatic sea level fluctuations is clearly wrong and, consequently, they cannot be used to support eustatic scenarios.

Hardgrounds as "Discontinuity Surfaces"

Miller (1984, figs. 4A-B) suggested that planar corrosion surfaces, or hardgrounds, at the base of both the *Cordylodus proavus* Zone and the *Missisquoia typicalis* Subzone in Texas were "discontinuity surfaces" produced by subaerial erosion during the twin pulses of the LREE. Hardgrounds are ubiquitous in carbonate sequences (for Upper Cambrian examples, see Markello and Read, 1981, fig. 7B; Brett and others, 1983, figs. 2, 3) as local features that form rapidly under submarine conditions (Shinn, 1969; Dravis, 1979). They do not, by themselves, indicate either subaerial erosion or significant temporal hiatuses. Independent biostratigraphic evidence for a discontinuity exist only at the base of the *Missisquoia typicalis* Subzone at some sections in Texas in which the thin *Missisquoia depressa* Subzone is missing (Miller, 1984, p. 49). This subzone has, however, been identified in other regions, including nearby areas in Texas, as well as in Utah and Oklahoma (Miller and others, 1982), District of Mackenzie (Ludvigsen, 1982) and southern Alberta (Westrop, 1986). A local absence of a thin subzone does not require and explanation involving emergence and subaerial erosion of an entire continent. Moreover, the biostratigraphic significance of these hardgrounds diminishes greatly as one discovers that there are at least three other "discontinuity surfaces" in the 10 m of strata underlying the putative regression in the Texas section (J.F. Taylor, *In* Palmer, 1984, p. 606).

Miller (1984, fig. 4C) also illustrated a lime mudstone-grainstone contact at the base of the *Cordylodus proavus* Zone in Utah that he interpreted as a "?microkarst surface" formed by a eustatic sea level fall. This surface bears little resemblance to documented paleokarst surfaces (for example, James and Choquette, 1984) and, in our opinion, the grainstone appears to be a tempestite with a scoured base (compare to Kreisa, 1981, fig. 4D; Aigner, 1982, figs. 2C, 3D).

Debris Flow Deposits

Miller (1984, p. 53) claimed that the sea level drop at the base of the LREE resulted in the emplacement of thick debris flows and turbidites in a slope succession of the Hales Limestone in Tybo Canyon, Nevada. The attributed origin is less than convincing; not only because the underlying strata also contain debris flows and turbidites, but also because (according to Miller, "the later part of the LREE is represented at Tybo Canyon by massive slump and slide deposits that accumulated during the postulated period of slowly rising sea level." If both a *sea level drop* and a *sea level rise* can be held responsible for deposition of debris flows, then we conclude that such deposits are not of much use in documenting eustatic changes.

It is well known that sea level fall exposes shallow shelves to erosion which results in canyon incision and deposition of debris flows whose clasts are lithologically heterogeneous and biostratigraphically mixed. Such debris flows contrast with slumps and resedimented slope and shallow water clasts, ubiquitous in carbonate slope sequences, that are the normal result of margin accretion and progradation. Debris flows in the Sunwaptan-Ibexian boundary interval in Nevada and Newfoundland consist of clasts of congruent ages and of local derivation (Cook and Taylor, 1977; Fortey and others, 1982; James and Stevens, 1986). They provide no evidence of a eustatic sea level fall.

Major Unconformities

The best and most unequivocal evidence for a regression is a major unconformity, and a eustatic origin is likely if it can be recognized on many continents. In support of the LREE, Miller (1984, p. 48) quoted Jaanusson (1979, p. 138-139):

> "The Ordovician Period began with a transgression that was one of the most extensive in the Paleozoic. Over almost the whole of Europe and North Africa there is a conspicuous break at the base of the Lower Tremadocian..."

Unfortunately, Miller did not complete this quotation. Jaanusson neither suggested nor implied that the transgression was associated with an initial regression. Furthermore, Jaanusson continued:

> "... and what appear to be continuous sequences from Cambrian to the Ordovician are known only in some areas of southern Scandinavia and along a belt to central Poland. In most of continental Europe and northern Africa the break comprises the entire Upper Cambrian and on the Russian platform east of the Baltic also the Middle Cambrian. In extensive Arctic areas, such as the Canadian Arctic Archipelago, Greenland, and Spitzbergen, Lower Tremadocian rests on Middle Cambrian, in southern Mexico on Precambrian, and in the allochtonous Taconic sequence of New York on Lower Cambrian. The widespread occurrence of the break suggests an eustatic control of the transgression."

Subsequent work as narrowed the gap in the Arctic Archipelago (Palmer and others, 1981: Nowlan, 1985) and has demonstrated that it is nonexistant in the Taconic allochthon (Landing, 1976). However, it is clear that in most of the areas discussed by Jaanusson, the sub-Tremadocian break is much longer than the brief eustatic sea level drop envisaged by Miller. For example, Miller's (1984, p. 54) discussion of the succession at Oaxaca, Mexico, where Tremadocian strata rest unconformably on basement dated at 1-1.2 billion years (Pantoja-Alor, 1970, p. 67) is entirely irrelevant to the purported brief pre-Tremadocian regression. It does, however, attest to the extent of the basal Tremadocian transgression.

Unconformities must be regional in extent and of short duration in order to qualify as stratigraphic evidence for a eustatic sea level drop. The one between the Sunwaptan St. Charles Formation and the Ibexian Garden City Formation in northern Utah documented by Taylor and Repetski (1985) is neither and, contrary to the authors' claim (p. 237), this disconformity cannot be identified with the LREE.

Contrary to the suggestions of both Fortey (1984, p. 41) and Miller (1984, p. 54), the absence of the highest Merionethian Series (*Acerocare* Zone) in parts of Scandinavia is not compelling evidence for a eustatic regression during the LREE. In Baltica, the entire Upper Cambrian is highly condensed (thicknesses between 20 and 60 m; Martinsson, 1974) with numerous breaks, and it is doubtful that any special significance should be attached to the absence of a single zone. The *Acerocare* Zone break was merely the latest of four similar hiatuses in Upper Cambrian strata of Scandinavia (Martinsson, 1974, fig. 5); the only difference is that the ensuing Tremadocian transgression was much more extensive than those in the Upper Cambrian.

Glaciogenic Deposits

Having accepted the reality of brief eustatic regressions during the LREE, Miller (1984, p. 55-56; see also Erdtmann and Miller, 1981) then speculated that these regressions were glacial in origin. Discovery of glaciogenic sediments of the same age as the LREE would certainly lend circumstantial support for these speculations. Miller noted that Castaos and Rodrigo (1978), showed tilloids at about the right level in a summary stratigraphic section for the lower Paleozoic of west-central Bolivia. However, the latest Cambrian age attributed to these rocks is no more than a guess. The supposed tilloids occur in the Avispas Formation, the upper of two formations comprising the 2000 m thick Limbo Group which rests unconformably on Precambrian crystalline basement and is, in turn, overlain by shales of the Capinota Formation, dated as Llanvirnian by graptolites and trilobites (Brockmann and others, 1972). Regardless of whether the sandstones, shales and conglomerates of the Avispas Formation were deposited by turbidity currents (Brockmann and others, 1972) or by marine ice (Rocha-Campos, 1976), the Limbo Group cannot contribute age or environmental information to fuel speculations on glacio-eustatic fluctuations near the Cambrian-Ordovician boundary because it is entirely devoid of fossils. Any tilloids that might be present could equally well record the Varangian glaciation at the base of the Vendian.

Conclusions about "Eustatic Events"

The lithologic and stratigraphic evidence brought forth by Miller (1984) and Fortey (1984) fails to demonstrate a eustatic sea level drop near the Cambrian-Ordovician boundary. Their lithologic conclusions are based on unfounded assumptions about controls on the distribution of carbonate lithofacies in peritidal sequences. Hardgrounds are not unconformities. Debris flows do not form only at low sea level stands. Brief hiatuses are common in condensed sequences at higher paleolatitudes (Baltica); they are not restricted to the Cambrian-Ordovician boundary interval. Glaciogenic deposits of an age close to the Cambrian-Ordovician boundary have not been identified.

EARLY ORDOVICIAN TRANSGRESSION

All investigators have accepted the reality of an early Ordovician transgression; only the timing of its start is in question. According to Miller (1984, fig. 1), the lower regressive pulse of the LREE is entirely pre-Tremadocian in age, and the start of the transgression following the higher regressive pulse is close to the base of the Tremadocian Series. By contrast, Fortey (1984, p. 40, figs. 3, 4) saw evidence of a single regression in the basal Tremadocian and, therefore, viewed the start of the subsequent transgression as being somewhat later than that of Miller (Figure 2).

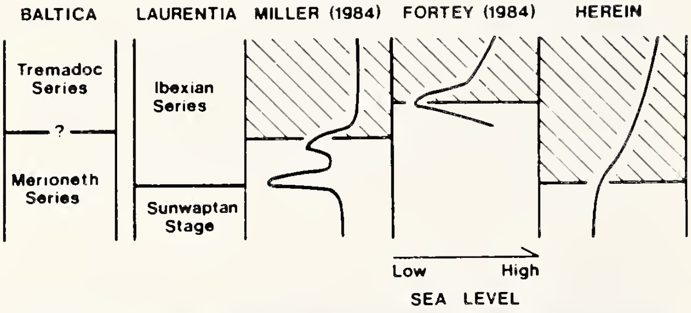


Figure 2 **Comparison of Miller's and Fortey's sea level curves and one showing the simple eustatic sea level rise preferred in this paper. Shaded portions of figure indicate interpreted onset of an Early Ordovician transgression.**

We have demonstrated that the evidence for a regression is either illusory or else insufficient in scope to cause the required results. The lithofacies and biofacies data near the Sunwaptan-Ibexian boundary in Laurentia indicate that the Early Ordovician transgression started in pre-Tremadocian time and at the base of the Ibexian Series (Figure 2; Ludvigsen and Westrop, 1985).

In western Canada, the Sunwaptan-Ibexian boundary is a Grand Cycle boundary which separates light-colored shallow-water carbonates below from either dark-colored argillaceous lime mudstone (District of Mackenzie; Ludvigsen, 1982) or calcareous shales and tempestites (southern Alberta; Aitken, 1966; Westrop, 1986). On a regional scale, this records flooding of the outer part of the carbonate belt and an overall landward lithofacies shift. The vertical and lateral sequence of trilobite biofacies indicates the same. The *Larifugula* Biofacies (Ludvigsen and Westrop, 1983) above the Grand Cycle boundary at the base of the Ibexian in western Canada includes off-platform trilobites, such as olenids and agnostids.

We identify the start of the Early Ordovician transgression as a sea level rise which is expressed as both a lithofacies and biofacies shift in western North America at the base of the Ibexian Series. On the outer platform, incursions of off-platform litho- and biofacies persist upsection through the lower Ibexian at least as high as a level correlative with the basal Tremadocian (Ludvigsen, 1982). Therefore, the lower part of our interpreted early Ordovician transgression extends up to levels where Miller and Fortey initiate their Tremadocian transgressions. We conclude that there is evidence of only a single transgression which started at the base of the Ibexian in North America and impinged on other continents at slightly different early Tremadocian times. This transgression was not interrupted by significant and mappable regressive episodes.

IMPLICATIONS FOR THE BASE OF THE ORDOVICIAN SYSTEM

The International Working Group on the Cambrian-Ordovician Boundary decided in July, 1985, that the base of the Ordovician System should be drawn with reference to conodont biostratigraphy at a horizon close to the first appearance of planktic graptolites near the base of the Tremadocian Series. The putative basal Ibexian and basal Tremadocian regression or regressions will inevitably be a consideration on which stratigraphic level in which area is, or is not, appropriate to serve as a stratotype. Already, the regressions have been cited as important negative factors in the Circular distributed by the Working Group. Some horizons have been labelled as inappropriate because they supposedly correspond to drops in sea level and represent disconformities. Other horizons have been judged to be superior because they are located within successions deposited during sea level rises. Even if the evidence for these sea level drops were compelling, use of such criteria in evaluating potential horizons is misguided. The stratotype potential of a particular horizon in a measured section must be evaluated by empirical biostratigraphic *data*; it cannot be prejudged by lithostratigraphic *inferences*.

REFERENCES CITED

Aigner, T.A. 1982. Calcareous tempestites: Storm-dominated stratification in Upper Muschelkalk limestones (Middle Trias, SW Germany). *In* Einsele, G. and Seilacher, A. (eds.), Cyclic and Event Stratification, Springer-Verlag, pp. 180-198.

Aitken, J.D. 1966. Middle Cambrian to Middle Ordovician cyclic sedimentation, southern Rocky Mountains of Alberta. Bull. Can. Petrol. Geol. 14:405-441.

Brett, C.E., Liddel, W.D., and Derstler, K.L. 1983. Late Cambrian hard substrate communities from Montana/Wyoming: the oldest known hardground encrusters. Lethaia 16:281-289.

Brockmann, C., Castaos, A., Suarez, R.., and Tomasi, R. 1972. Estudio geologico de la Cordillera Oriental de los Andes en la zona central de Bolivia (Region de Chapare). Soc. geol. Boliviano Bol. 18:3-36.

Castaos, A. and Rodrigo, G.L.A. 1978. Sinopsis estratigrafica de Bolivia; 1 parte; Paleozoico. Acad. Nac. Ciencias Bolivia, 146 p.

Cook, H.E. and Taylor, M.E. 1977. Comparison of continental slope and shelf environments in the Upper Cambrian and lowest Ordovician of Nevada. Soc. Econ. Paleont. Mineral. Spec. Pub. 25:51-81.

Cowie, J.W., Rushton, A.W.A., and Stubblefield, C.J. 1982. A correlation of Cambrian rocks in the British Isles. Geol. Soc. London Spec. Rept. 2, 42 p.

Dravis, J. 1979. Rapid and widespread generation of Recent oolitic hardgrounds on a high energy Bahamian platform, Eleuthra Bank, Bahamas. J. Sed. Pet. 49:195-208.

Erdtmann, B.D. and Miller, J.F. 1981. Eustatic control of lithofacies and biofacies changes near the base of the Tremadocian. *In* Taylor, M.E. (ed.), Short Papers for the Second International Symposium on the Cambrian System. U.S. Geol. Surv. Open-File Rept. 81-743, pp. 78-81.

Fortey, R.A. 1984. Global earlier Ordovician transgressions and regressions and their biological implications. *In* Bruton, D.L. (ed.), Aspects of the Ordovician System. Palaeont. Cont. Univ. Oslo 295, pp. 37-50.

———, Landing, E., and Skevington, D. 1982. Cambrian-Ordovician boundary sections in the Cow Head Group, western Newfoundland. *In* Bassett, M.G. and Dean, W.T. (eds.), The Cambrian-Ordovician Boundary: Sections, Fossil Distributions, and Correlations. Natl. Mus. Wales Geol. Ser. 3, pp. 95-129.

Hallam, A. 1984. Pre-Quaternary sea-level changes. Ann. Rev. Earth and Planet. Sci. 12:205-243.

Jaanusson, V. 1979. Ordovician. *In* Robison, R.A. and Teichert, C. (eds.), Treatise on Invertebrate Paleontology, Part A, Introduction. Geol. Soc. Amer, pp. 136-166.

James, N.P. and Choquette, P.W. 1984. Diagenesis – 9. Limestones – the meteoric diagenetic environment. Geosci. Can. 11:161-194.

——— and Stevens, R.K. 1986. Stratigraphy and correlation of the Cow Head Group (Cambro-Ordovician), western Newfoundland. Geol. Surv. Can. Bull. 366.

Kreisa, R.D. 1981. Storm-generated sedimentary structures in subtidal marine facies with examples from the Middle and Upper Ordovician of southwestern Virginia. J. Sed. Pet. 51:823-848.

Landing, E. 1976. Tremadocian conodonts from the Taconic allochthon, eastern New York: Implications for the trans-Atlantic correlation of the earliest Ordovician. Geol. Soc. Amer. Abstracts with Programs 8:488-489.

Laporte, L.F. 1968. Recent carbonate environments and their paleoecologic implications. *In* Drake, E.T. (ed.), Evolution and Environment. Yale Univ. Press, pp. 229-258.

Ludvigsen, R. 1982. Upper Cambrian and Lower Ordovician trilobite biostratigraphy of the Rabbitkettle Formation, western District of Mackenzie. Roy. Ont. Mus. Life Sci. Cont. 134, 188 p.

——— and Westrop, S.R. 1983. Trilbite biofacies of the Cambrian-Ordovician boundary interval in northern North America. Alcheringa 7:301-319.

——— and ———. 1985. Three new Upper Cambrian stages for North America. Geol. 13:139-143.

Markello, J.R. and Read, J.F. 1981. Carbonate ramp-to-deeper shale shelf transitions of an Upper Cambrian intrashelf basin, Nolichucky Formation, southwest Virginia Appalachians. Sedimentol. 28:573-597.

Martinsson, A. 1974. The Cambrian of Norden. *In* Holland, C.H. (ed.), Lower Palaeozoic Rocks of the World 2. Cambrian of the British Isles, Norden and Spitsbergen. John Wiley and Sons, London, pp. 185-283.

Miller, J.F. 1978. Upper Cambrian and lowest Ordovician conodont faunas of the House Range, Utah. *In* Miller, J.F. (ed.), Upper Cambrian to Middle Ordovician conodont faunas of western Utah. Southwest Missouri State Univ. Geosci. Ser. No. 5, pp. 1-33.

——— 1984. Cambrian and earliest Ordovician conodont evolution, biofacies, and provincialism. *In* Clark, D.L. (ed.), Conodont biofacies and provincialism. Geol. Soc. Amer. Spec. Paper 196, pp. 43-68.

———, Taylor, M.E., Stitt, J.H., Ethington, R.L., Hintze, L.F., and Taylor, J.F. 1982. Potential Cambrian-Ordovician boundary stratotype sections in the western United States. *In* Bassett, M.G. and Dean, W.T. (eds.), The Cambrian-Ordovician Boundary: Sections, Fossil Distributions, and Correlations. Natl. Mus. Wales Geol. Ser. 3, pp. 155-180.

Nowlan, G.S. 1985. Late Cambrian and Early Ordovician conodonts from the Franklinian Miogeosyncline, Canadian Arctic Islands. J. Paleont. 59:86-122.

Palmer, A.R. 1984. The biomere problem: evolution of an idea. J. Paleont. 58:599-611.

__________, Cowie, J.W., and Eby, R.G. 1981. A Late Cambrian (Dresbachian, *Crepicephalus* Zone) fauna from the Boothia Peninsula, District of Franklin. Geol. Surv. Can. Bull. 300:1-6.

Pantoja-Alor, J. 1970. Rocas sedimentarias paleozöicas de la region centro-septentrional de Oaxaca. *In* Segura, L.R. and Rodrigues-Torres, R. (eds.), Libro-Guia de la Excursion Mexico-Oaxaca. Soc. geol. Mexicana, pp. 67-84.

Pratt, B.R. and James, N.P. 1986. The St. George Group (Lower Ordovician) of western Newfoundland: tidal flat island model for carbonate sedimentation in shallow epeiric seas. Sedimentol. 33:313-343.

Rocha-Campos, A. 1976. Glaciacoes paleozöicas na America do sul: Uma revisao. Primer Congreso geologicol chileno, III, pp. 95-142.

Shinn, E.A. 1969. Submarine lithification of Holocene carbonate sediments in the Persian Gulf. Sedimentol. 12:109-144.

Taylor, M.E. and Repetski, J.E. 1985. Early Ordovician sea-level changes in northern Utah and southeastern Idaho. Utah Geol. Assoc. Pub. 14:237-247.

Westrop, S.R. 1986. Trilobites of the Upper Cambrian Sunwaptan Stage, southern Canadian Rocky Mountains, Alberta. Palaeontogr. Can.

The Gamachian Stage and Fauna 13

Alexander D. McCracken and Godfrey S. Nowlan
Geological Survey of Canada, Ottawa

ABSTRACT

Conodont Fauna 13 is characterized by *Gamachignathus ensifer* McCracken and others and *G. hastatus* McCracken and others and has been used as an informal acme zone. Relative abundance values have been calculated to compare Late Ordovician faunas of Anticosti Island, Quebec, with those from other localities. The values are low in the Vauréal Formation. The dramatic increase in the overlying Ellis Bay Formation (average about 32 percent) is coincident with the base of the Fauna 13 interval.

The first occurrence of *Gamachignathus ensifer* in the Vauréal Formation is defined as a formal first-appearance conodont biohorizon. It marks the base of the *G. ensifer* conodont Biozone that ranges from the upper Richmondian through Gamachian. The first appearance of *G. hastatus* and a subspecies of *Pseudobelodina* and the last occurrence of *Plectodina* in the Vauréal Formation also may be useful biohorizons. *Amorphognathus* does not occur in upper Fauna 13, and, thus, correlation with the *A. ordovicicus* Biozone is uncertain.

The upper limit of both Fauna 13 and the *G. ensifer* Biozone is defined by the lower limit of the *Ozarkodina hassi-O. oldhamensis* biointerval zone. The lowest strata of the latter zone contain a mixed conodont fauna that includes taxa usually regarded as Silurian. The basal Silurian *Parakidograptus acuminatus* graptolite Biozone is not known in Anticosti strata but is likely higher than these "Silurian" conodonts.

Gamachignathus probably favoured cool-water environments, and immigrated to areas marginal to Laurentia in the latest Ordovician in response to glacial cooling. It is unlikely that *Gamachignathus* and Fauna 13 will be found in cratonic areas.

INTRODUCTION

The "Gamachian Series" was erected by Schuchert and Twenhofel (1910, p. 700) as the uppermost part of the Upper Ordovician "Cincinnatic System." They indicated that strata characteristic of this interval are present around Ellis Bay (formerly Gamache Bay) on western Anticosti Island, Quebec (Figure 1), and they believed (ibid., p. 701) that the Gamachian comprised "deposits later in age than the youngest Richmondian of Indiana and Ohio and older than the Anticosti series." Despite this assertion and the further elaboration on the faunas from the Ellis Bay Formation by Twenhofel (1928), the term Gamachian was largely ignored until recently.

Studies of graptolites from Anticosti Island (Riva, 1969; Riva and Petryk, 1981) and the Richmondian of Ohio (Mitchell and Bergström, 1977) show that the Gamachian Stage is a necessary stadial entity because the top of the North American Upper Ordovician standard sequence in the Cincinnati, Ohio, region is statigraphically incomplete (Figure 1). However, formal reestablishment of the Gamachian Stage was not advocated until McCracken and Barnes (1981a) published a study of conodonts from three sections of the Ellis Bay Formation on Anticosti Island. They recognized a distinctive faunal assemblage that they termed "Fauna 13" and indicated that it succeeded Fauna 12. The latter assemblage was recognized previously as youngest Ordovician by Sweet and others (1971).

Restudy of several fossil groups from Ordovician-Silurian boundary strata on Anticosti Island and adjacent Gaspésie, Quebec, was summarized in Lespérance (1981) and provided additional support for recognition of the Gamachian Stage. Rather than establishing a new series of limited stratigraphic extent, the Gamachian Stage is included as the uppermost stage within the Cincinnatian Series. This follows the common stratigraphic practice of extending the Cincinnatian Series to the base of the Silurian. It is important to clarify the nature of Fauna 13 and its relationship to the Gamachian Stage, in order to define and refine Upper Ordovician stratigraphy.

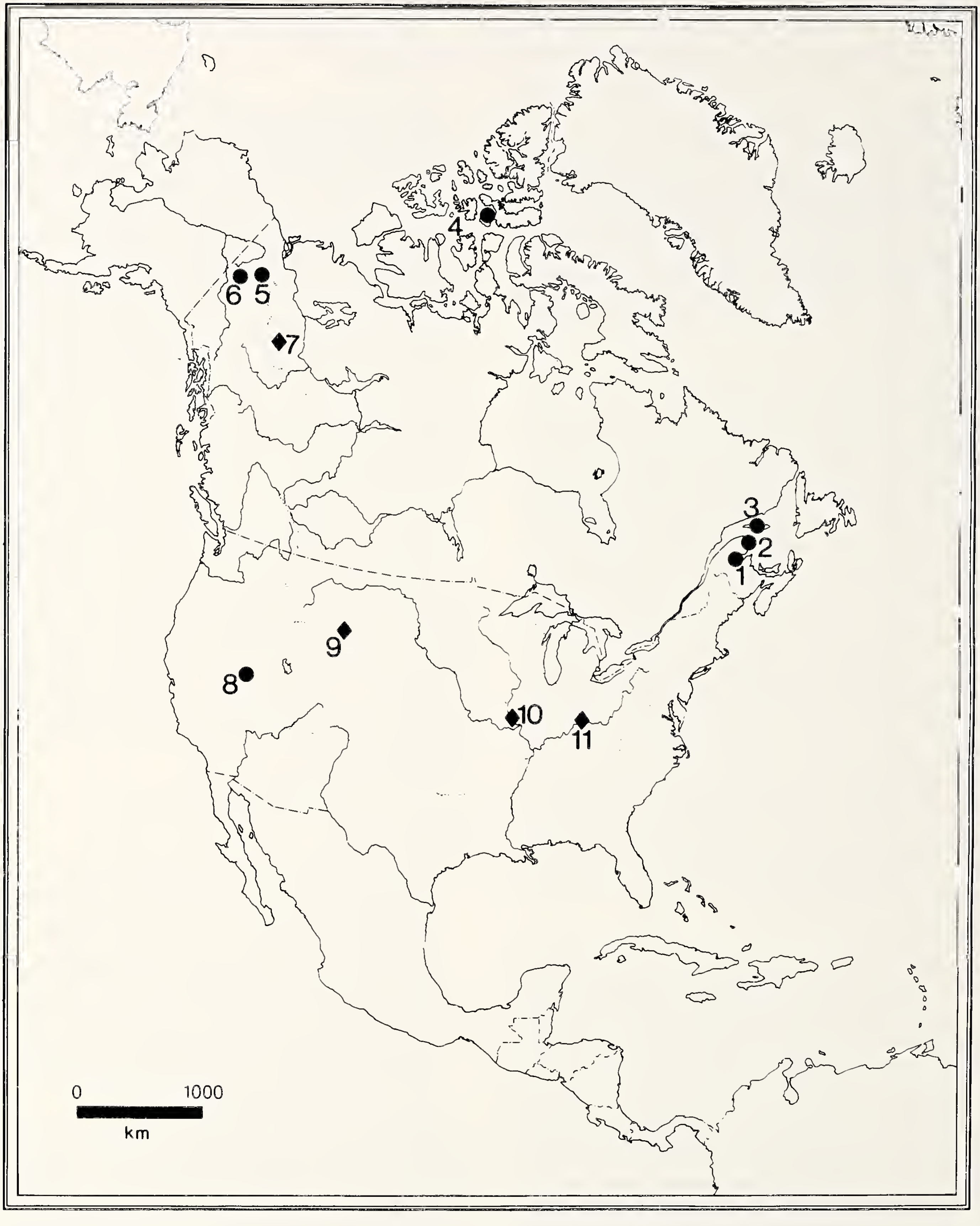
DEFINITION OF FAUNA 13

Fauna 13, as proposed by McCracken and Barnes (1981a, p. 64) is

> "characterized by the presence of *Gamachignathus ensifer* and *G. hastatus*. It is uncertain whether the absence of species of *Plectodina* within the Ellis Bay fauna is also diagnostic of Fauna 13 elsewhere. Although *Gamachignathus* first appears in the upper Vauréal Formation, the base of Fauna 13 is taken at the level where this genus becomes a dominant component of the fauna. This level is at the base of the Ellis Bay Formation and Fauna 13 ranges into the base of Member 6 of this formation."

(Member 6 in the above quote is *sensu* Bolton [1972]; the text below follows Bolton [ibid.] for Member 1 through the base of Member 6; Member 7 is that of Petryk [1981]).

The faunal intervals (Faunas 1-12) of Sweet and others (1971) have been treated as biostratigraphic units even


1
2
3
4
5
6
7
8
9
10
11
0
1000
km

though they were never intended to be used as such (Sweet, 1984). In name, Fauna 13 follows this sequence of faunas but, from its inception, it has been used in the stratigraphic sense as evidence for the re-establishment of the base of the Gamachian Stage (McCracken and Barnes, 1981a, p. 64)

Most species occurring within Fauna 13 are also found in Fauna 12 of the underlying Vauréal Formation (Nowlan and Barnes, 1981). *Aphelognathus* aff. *A. grandis* Branson, Mehl and Branson may represent a new Gamachian species, but its elements are small and delicate. This makes comparisons with other species of *Aphelognathus* difficult. *Amorphognathus* cf. *A. ordovicicus* Branson and Mehl *sensu* McCracken and Barnes (1981a) was distinguished by its holodontiform element but it is questionable whether this element is much different from the equivalent element of *A. ordovicicus* from the Vauréal Formation and other strata. *Staufferella inaligera* McCracken and Barnes is rare in the Ellis Bay Formation, and only 7 of the diagnostic symmetrical elements are known. The most reliable (and abundant) index species in the formation, then, are the two *Gamachignathus* species named above; the fauna or an equivalent biostratigraphic unit must be defined using these two species.

McCracken and Barnes (1981a, b) referred to these taxa at the generic level in their discussions, but it is implicit that Fauna 13 was defined at the specific level. This must be strongly emphasized, and any future discovery of the genus does not automatically indicate Fauna 13. Such a discovery in older or younger strata would extend the generic range but would not necessarily change the biostratigraphic significance of these two species or Fauna 13.

The original definition of Fauna 13 (cited above) has been misinterpreted. The Ordovician correlation chart for the United States (Ross and others, 1982, Sheet 1) used the term "*Gamachignathus* Fauna," and Savage and Bassett (1986, p. 683) referred to "post-*ordovicicus* Biozone faunas" as "*Gamachignathus* faunas." These terms are incorrect. Firstly, if the biozone or fauna is to be named formally, it must be after the species, not the genus. Secondly, at least the lower part of the Fauna 13 interval may be coeval with the upper part of the *Amorphognathus ordovicicus* Biozone, particularly if the elements referred to *A.* cf. *A. ordovicicus* by McCracken and Barnes (1981a) from the lower half of the Ellis Bay Formation actually are *A. ordovicicus*. McCracken and Barnes (1981a, p. 73) speculated that the different holodontiform element of *A.* cf. *A. ordovicicus* might reflect an evolutionary development that is applicable to refinement of the zonal scheme but preferred to place Fauna 13 within the *A. ordovicicus* Biozone (ibid., p. 64, fig. 11).

The base of the Fauna 13 interval is in basal strata of the Ellis Bay Formation (sample E02, Section IA of McCracken and Barnes, 1981a) where specimens of *Gamachignathus ensifer* McCracken, Nowlan and Barnes and *G. hastatus* McCracken and others become numerically dominant. However, this level is not the first appearance of either species (Figure 2). Specimens of *G. ensifer* first occur in the lower member of the exposed part of the Vauréal Formation and are present rarely throughout the rest of the formation (Nowlan and Barnes, 1981). Similarly, *G. hastatus* has an occurrence slightly higher in the Vauréal Formation (McCracken and others, 1980, p. 108; see Nowlan and Barnes, 1981, pl. 3, fig. 21; see also "Biohorizons and Biozones"). Therefore, the Fauna 13 interval cannot be regarded as a taxon or taxa range-zone.

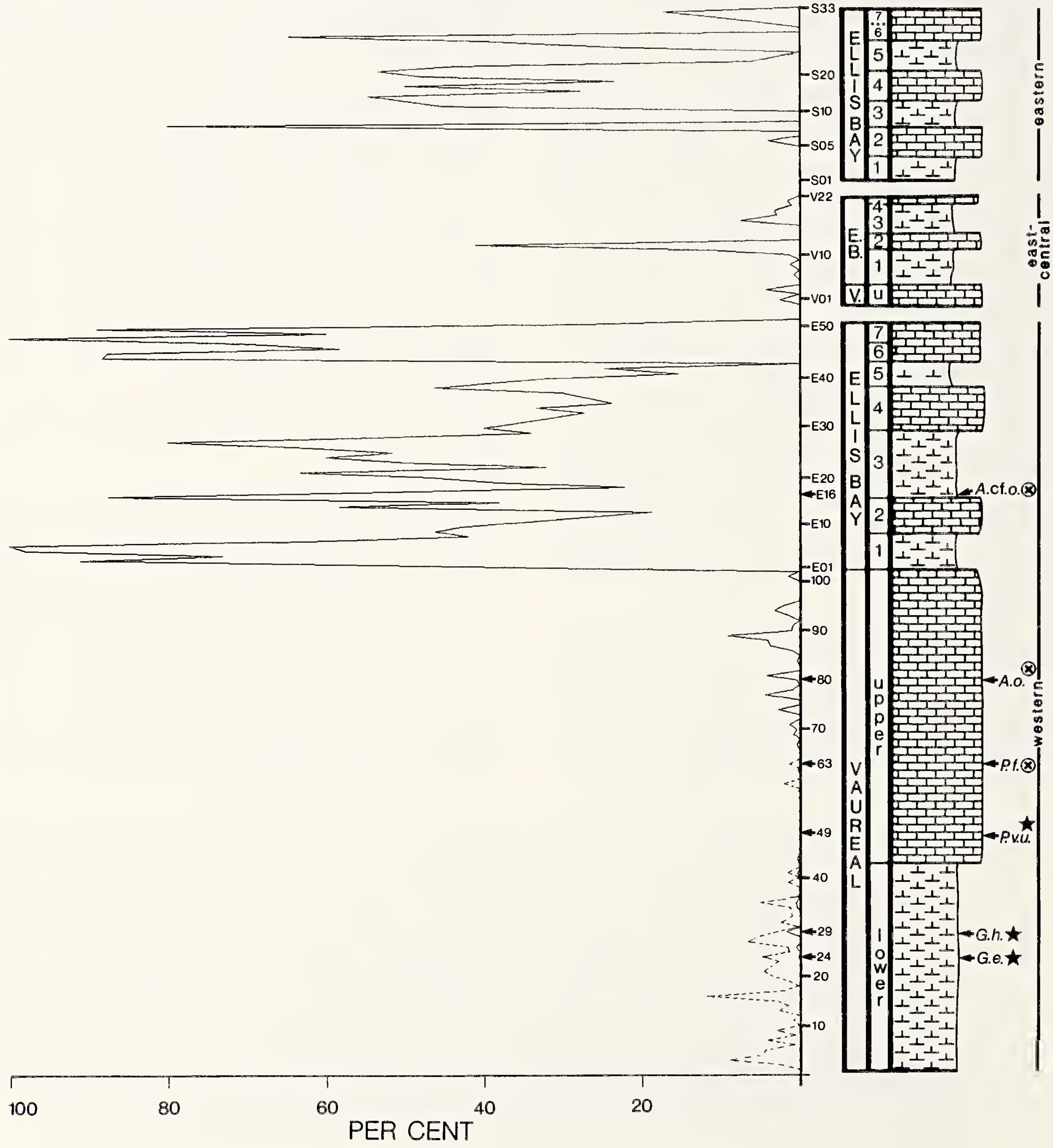
In noting the occurrence of *Gamachignathus* in the upper part of the Vauréal Formation and defining the first appearance of Fauna 13 where "this genus" (i.e., as represented by *G. ensifer* and *G. hastatus*) dominates the fauna, McCracken and Barnes (1981a, p. 64) described an informal acme zone. However, an acme zone has an inherent problem: how to describe or define the "maximum development" of a taxon or taxa. It also is a difficult concept to apply when calculations are based on low-yield samples. In order to illustrate the marked changes in relative abundance of specimens of the two species of *Gamachignathus* in strata of Anticosti Island

Figure 1 North American locations of strata and conodont occurrences discussed in the text. Circles represent strata bearing *Gamachignathus ensifer* McCracken, Nowlan and Barnes; this species does not occur in strata indicated by the diamonds. Strata and localities are: (1) Matapedia and Grog Brook groups, Matapedia area, New Brunswick and Quebec (Nowlan, 1981, 1983); (2) Matapedia Group and White Head Formation, Percé area, Quebec (Nowlan, 1981); (3) Vauréal and Ellis Bay formations, Anticosti Island, Quebec (Nowlan and Barnes, 1981; McCracken and Barnes, 1981a, b); (4) Allen Bay Formation, Cornwallis Island, Northwest Territories (unpublished data); (5) Road River Group, upper Peel River, Yukon Territory (unpublished data); (6) Road River Group, Blackstone River, Yukon Territory (Lenz and McCracken, 1982); (7) Whittaker Formation, Avalanche Lake, Northwest Territories (Nowlan and others, *In press*); (8) Hanson Creek Formation, Nevada (Ross and others, 1979); (9) Upper Bighorn Group, Wyoming (Section 75SC of Sweet, 1979); (10) Edgewood Group, Noix Limestone, Clarksville, Missouri (McCracken and Barnes, 1982); (11) Cincinnatian Series, Cincinnati area, Ohio, Kentucky and Indiana.

and to compare them with other areas, we present a numerical comparison (Figure 2).

Elements of the two species of *Gamachignathus* comprise 0.3 per cent of the conodont fauna in strata of the Vauréal Formation that are above the first occurrence of *Gamachignathus ensifer*. Their relative abundance in individual samples increases in the upper part of this interval that bears *Gamachignathus* but never exceeds 9 percent (Figure 2). Values are for strata from western Anticosti Island and are derived from data of Nowlan and Barnes (1981, table 1).

At the western section, in the Ellis Bay area (Sections IA, IB of McCracken and Barnes, 1981a), there is a dramatic increase in the relative abundance of *Gamachignathus* across the Vauréal-Ellis Bay formational boundary. *G. ensifer* and *G. hastatus* comprise about 47 per cent of the total conodont fauna in the Ellis Bay Formation; in individual samples with more than 100 speci-



mens, the relative abundance varies from 1 to 98 per cent (calculated from McCracken and Barnes, 1981a, tables 2, 3). The relative percentage values from two other sections of the Ellis Bay Formatin are: east-central, Vauréal River (Section II of McCracken and Barnes, 1981a), 17 percent; eastern, Salmon River (Section III), 33 per cent. The relatively low values for the Vauréal River section are partly due to the fact that most of Member 4 and Members 5 through 7 are poorly exposed and were not sampled. For the Ordovician of the Ellis Bay Formation from all sections, elements of *G. ensifer* and *G. hastatus* represent about 32 per cent of the conodont fauna (ibid., tables 1-6).

The relative abundance values for elements of *Gamachignathus ensifer* from strata of the Matapedia Group, Gaspésie, Quebec (Figure 1), are variable. In debris flows within deep basinal strata of this group in the Matapedia area, the value is about 22 per cent (Nowlan, 1981, p. 261). Strata of the White Head Formation in the Percé area (Figure 1), which probably represent somewhat shallower basinal conditions, yielded fewer specimens of the species. Nowlan (1981) reported *G. ensifer* from both units 3 and 4 of the White Head Formation, but recent stratigraphic revisions reported by Lespérance (1985) suggest that all occurrences of the species are from strata of unit 4 that directly underlie strata with a Hirnantian brachiopd fauna. Relative abundance values for *G. ensifer* in unit 4 of the White Head Formation range as high as 36 per cent but average about 7 per cent (values calculated from unpublished distribution tables).

Gamachignathus ensifer has been reported from one sample of the Hanson Creek Formation, Nevada (Figure 1), by Ross and others (1979, p. C11, table 2) where it occurs with rare plectospathodiform and spathognathodiform elements that have a Silurian aspect. *Amorphognathus* and *Plectodina* are notably absent (see "Biohorizons and Biozones", below). This single fauna from Nevada was compared by Ross and others (1979) to the fauna of the transitional zone (herein "mixed fauna") of McCracken and Barnes (1981a). *Gamachignathus ensifer* (as reconstructed by McCracken and others, 1980) composes about 53 per cent of the fauna.

In the Road River Group of northern Yukon (Figure 1), the upper Peel River occurrence of *Gamachignathus ensifer* is limited (0.6 per cent); at Blackstone River, the few elements of *G. ensifer* represent about 2 per cent of the fauna.

Nowlan (1983) reported *Gamachignathus ensifer* and *Icriodella* n. sp. A from the Grog Brook Group of northern New Brunswick (Figure 1). These two taxa are now believed to represent a new species of *Birksfeldia*, a genus that is closely related to *Gamachignathus*. In the Grog Brook Group, the relative abundance of *Birksfeldia* n. sp. is about 5 per cent. In Britain, elements of *Birksfeldia* also comprise about 5 per cent of faunas from the Cautleyan and Rawtheyan (calculated from Orchard, 1980).

Fauna 13 is based on an interval of strata on Anticosti Island that contains a high abundance of *Gamachignathus* elements. The transition from low to high relative abundance is abrupt and striking (Figure 2). This event also occurs in basinal strata of the White Head Formation, Gaspésie, Quebec, but its recognition in other areas is restricted by the paucity of continuous sections with samples containing *Gamachigathus*. Thus, in areas with limited occurrence of specimens of *G. ensifer* and *G. hastatus*, it will continue to be difficult to recognize Fauna 13.

BIOHORIZONS AND BIOZONES

The first occurrence of *Gamachignathus ensifer* at 51.5 m above the base of the exposed part of the Vauréal Formation (one element in sample 24 of Nowlan and Barnes, 1981, table 1) is herein regarded as a formal first-appearance conodont biohorizon and the base of the

Figure 2 Relative abundances of elements of *Gamachignathus ensifer* McCracken, Nowlan and Barnes and G. hastatus McCracken and others (solid line), and Plectodina species (broken line between samples 0-63) in strata of the Vaureal and Ellis Bay formations, Anticosti Island, Quebec. Sample numbers are the same as those used in Nowlan and Barnes (1981) for the Vauréal Formation, and McCracken and Barnes (1981a) for the Ellis Bay Formation. Sample levels and lithic sections are not to scale. Lithic symbols represent alternating members of limestone and argillaceous limestone. Member designations for Member 1 through the base of Member 6 are those of Bolton (1972); Member 7 is that of Petryk (1981). Locations of sections are: western (Oil River, and English Head to Anse aux Fraises of Nowlan and Barnes, 1981: Cap de la Vache-qui-Pisse to Ruisseau Barbarin, Sections IA, IB of McCracken and Barnes, 1981a); central (Vauréal River, Section II of McCracken and Barnes, 1981a); eastern (Salmon River, Sections IIIA-C of McCracken and Barnes, 1981a). Arrows represent occurrence levels of conodont species; first (star), last (circled cross). These species are: *Amorphognathus ordovicicus* Branson and Mehl (*A. o.*), *A.* cf. *A. ordovicicus* (*A.cf.o.*), *G. ensifer* (*G.e.*), *G. hastatus* (*G.h.*), *Plectodina florida* Sweet (*P.f.*), *Pseudobelodina vulgaris ultima* (*P.v.u.*).

Gamachignathus ensifer Biozone. This biozone is indicative of uppermost Richmondian (Figure 3). The upper limit of this zone is defined by the first appearance of "Silurian" species (=*Ozarkodina hassi-O. oldhamensis* biointerval zone). *G. ensifer* continues into the lowest part of the *O.? nathani* Biozone ('mixed fauna," Figure 3). The first occurrence of *G. hastatus* is higher in the same formation (66.5 m, sample 29); this species has only been found on Anticosti Island. The base of the *G. ensifer* Biozone is within the *Amplexograptus inuiti* graptolite Biozone of Riva and Petryk (1981).

Pseudobelodina vulgaris ultima Sweet (1979) is a latest Richmondian to post-Richmondian subspecies that was described from the Bighorn Group of Wyoming (Figure 1). Sweet (1984, Appendix) showed that there is a gap between the last occurrence of species of *Plectodina* and the first occurrence of *P. v. ultima*; in the Vauréal Formation, the ranges are partially concurrent (Figures 2, 3). The subspecies ranges upward from the middle of the exposed part of the Vauréal Formation (193 m, sample 49), and one of its elements was figured as *Belodina profunda* (Branson and Mehl) by Nowlan and Barnes (1981, pl. 7, fig. 12). This occurrence suggests that the upper part of this formation is latest Richmondian or younger Ordovician. *Pseudobelodina v. ultima* is rare in the Vauréal Formation, however. Its range has not been established in the overlying Ellis Bay Formation. McCracken and Barnes (1981a) reported elements of *B. profunda* that are conspecific with *P. vulgaris* Sweet from Members 1-4 of the Ellis Bay Formation. Reexamination of all samples from the Ellis Bay Formation in order to establish which subspecies is represented has not yet been possible, but those samples that have been reviewed contain only *P. vulgaris vulgaris*.

The last occurrence of species of *Plectodina* in the Vauréal Formation may be regarded as a last-appearance or extinction biohorizon (Figures 2, 3). *Plectodina* does not occur above the middle of the exposed Vauréal Formation (220 m above base, sample 63, Nowlan and Barnes, 1981, table 1), does not extend to the top of the Richmondian in the western Midcontinent (Sweet, 1979, fig. 3; 1984, Appendix), and is absent in post-middle Cautleyan strata of Britain (Orchard, 1980, fig. 3; Savage and Bassett, 1986).

The presence of *Plectodina*, rarity of *Gamachignathus ensifer*, and the apparent absence of the *Climacograptus extraordinarius* graptolite Biozone prompted Lenz and McCracken (1982) to assign a "late Fauna 12 age" to the conodont fauna from the Road River Group at Blackstone River, northern Yukon. This interpretation is also applicable to the fauna from the nearby section at Peel River. The fauna from the Vauréal Formation and the two from the Yukon are the only ones that include both *Gamachignathus* and *Plectodina*. Elsewhere, *Plectodina* is absent from other strata that bear *G. ensifer*, and from strata with *Birksfeldia*. The occurrence of *Plectodina* and the absence of *G. ensifer* supported a late Richmondian rather than a Gamachian age for the Noix Limestone at Clarksville, Missouri (Figure 1; McCracken and Barnes, 1982). Unless *Noixodontus*, which occurs with *Plectodina* and *Amorphognathus ordovicicus* in Missouri, is shown to be a strictly latest Ordovician genus, then *Plectodina* does not appear to range into the Gamachian.

The absence of species of *Plectodina* from the upper part of the Vauréal Formation and the Ordovician part of the Ellis Bay Formation is striking. It may be indicative of the uppermost Richmondian as was suggested cautiously by McCracken and Barnes (1981a, p. 64). Nowlan and Barnes (1981), however, have shown that

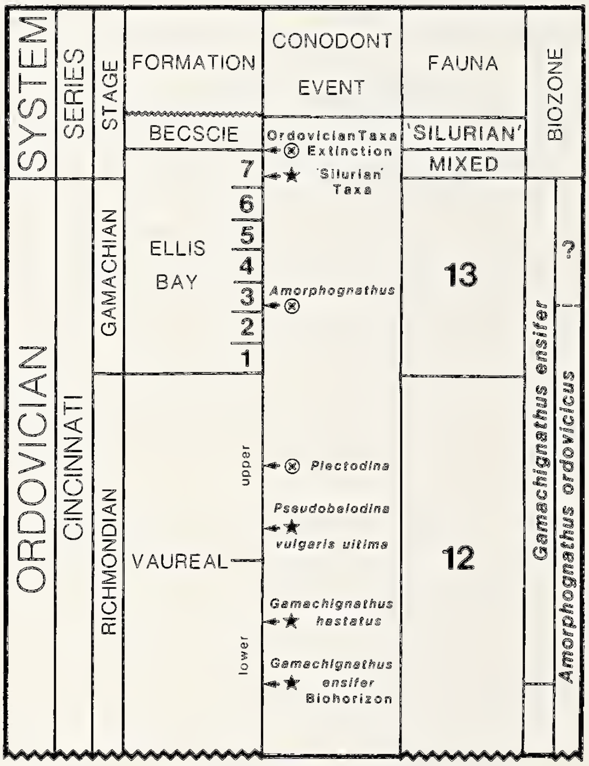


Figure 3 Correlation of strata on Anticosti Island, Quebec. Stratigraphic units are not scaled; zig-zag line indicates that the entire unit is not figured. Arrows represent occurrence levels of conodont species; first (star), last (circled cross). The term "Silurian" is in quotes because the conodont taxa have been traditionally regarded as Silurian, but probably occur first below the newly defined systemic base (i.e., *P. acuminatus* Biozone; see Holland, 1985). Only the *G. ensifer* Biohorizon and Biozone are formally defined in this study. The "mixed fauna" is that of the transitional zone of McCracken and Barnes (1981a).

the distribution of *Plectodina* in the Vauréal Formation may have been environmentally controlled and this could be an alternate reason for its absence in higher strata. A *Plectodina* community, if present during latest Richmondian and Gamachian time in the Anticosti Basin, remains undiscovered.

Elements of *Amorphognathus* are rare in the upper part of the Vauréal Formation and in the lower part of the Ellis Bay Formation. The last occurrence of the genus in the section on Anticosti Island (Figures 2, 3) is 4 m above the base of Member 3 of the Ellis Bay Formation (sample E16, Section IB of McCracken and Barnes, 1981a). This makes for an ambiguous correlation of the *A. ordovicicus* Biozone with the uppermost part of the Gamachian (Figure 3).

Several species of Ordovician conodonts become extinct near the top of Member 5 of the Ellis Bay Formation (McCracken and Barnes, 1981a). Conodonts of Silurian aspect first appear 0.9 m above the base of Member 7 at Ellis Bay (sample E48, Section IB); however, they occur mixed with Ordovician conodonts through the succeeding 1 m of strata (samples E48-E50). The massive extinction of Ordovician conodonts is complete at the top of this mixed interval which is approximately coincident with the base of the overlying Becscie Formation (Figure 3). Only four simple-cone genera survive the extinction event.

As presently defined, the base of the Silurian is at the base of the *Parakidograptus acuminatus* graptolite Biozone (Holland, 1985). This zone, unfortunately, cannot be recognized in eastern Canada. It is probable that the base of this zone is above the Ordovician-Silurian boundary as defined on the basis of conodonts. It may, therefore, be necessary to recognize an additional "Ordovician" conodont fauna that would include species presently considered to be of Silurian aspect (e.g., *Ozarkodina hassi* [Pollock, Rexroad and Nicoll], *O. oldhamensis* [Rexroad], *Oulodus*? *kentuckyensis* [Branson and Branson], *O.*? *nathani* McCracken and Barnes). For a full discussion of the correlation of the Ordovician-Silurian boundary see Lespérance (1985).

PALEOECOLOGY OF GAMACHIGNATHUS AND FAUNA 13

Fauna 13 was described from the Anticosti Basin, a depositional centre marginal to Laurentia that preserves a thick sequence of Late Ordovician and Early Silurian sediments. All presently known occurrences of *Gamachignathus ensifer* are also from areas marginal to the continent (Figure 1). McCracken and others (1980) suggested that the apparatus type and element morphology of *Gamachignathus* indicated a North Atlantic Province ancestry and, thus, a preference for cooler or deeper waters. These observations support the suggestion that Fauna 13 is an offshore fauna, but do not necessarily indicate that it is partly coeval with Fauna 12 as has been suggested by Sweet (1984, fig. 2). McCracken and Barnes (1981a) implied that Fauna 13 was absent from the midcontinent due to a glacio-eustatic hiatus. They also invoked environmental control to explain the "delayed" dominance of species of *Gamachignathus* in the more nearshore sections at the eastern end of Anticosti Island.

From its first appearance in the Vauréal Formation, *Gamachignathus ensifer* does not show a preference for any particular depositional environment. It is present at several levels in the three ecozones (representing shallow to deep subtidal conditions) recognized by Nowlan and Barnes (1981) for conodonts of the Vauréal Formation.

Elements of *Gamachignathus ensifer* and *G. hastatus* occur in a variety of shallow subtidal environments within the Ellis Bay Formation. These include (1) nearshore carbonate, rich in coarse clastic material, (2) intermediate and offshore carbonate, with little to much fine clastic material, and (3) biohermal carbonate. The relative abundance of *Gamachignathus* species is generally greater in offshore than in nearshore environments. It fluctuates throughout the Ellis Bay Formation (Figure 2), but a simple, direct relationship between sediment lithology and the two species of *Gamachignathus* is not evident (McCracken and Barnes, 1981a, fig. 13).

Gamachignathus ensifer is rare in siliciclastic strata (Road River Group) that represent a basinal trough near a carbonate- and fine clastic-rich slope or platform edge in the Yukon (Figure 1; Lenz and McCracken, 1982). Only one (at Peel River) of the two Yukon beds that contain *G. ensifer* shows sedimentary evidence of mass-flow from platform margins. Farther to the south in the Northwest Territories, *Gamachignathus* is not known in Upper Ordovician strata (Whittaker Formation) that are lithologically transitional between carbonate platform strata to the east and fine siliciclastics to the west (Figure 1; Nowlan and others, *In press*). *G. ensifer* is rare in carbonate strata near fine siliciclastic facies on Cornwallis Island (Figure 1; unpublished data).

In the Matapedia Basin within the Appalachian Orogen of eastern Canada, *Gamachignathus ensifer* occurs both in ribbon limestone of the White Head Formation and in grainstone units that probably represent distal debris flows in the deeper parts of the basin (Figure 1; Nowlan, 1981).

The proliferation of elements of *Gamachignathus ensifer* and *G. hastatus* in strata of Anticosti Island, in which Fauna 13 was originally recognized, may be environmentally controlled; however, it is unrealistic to expect any organism to be immune from environmental influences.

FAUNA 13: A DIACHRONOUS OR SYNCHRONOUS APPEARANCE?

In the Ellis Bay Formation, Fauna 13 occurs within the first 2 m of Member 1 in the stratotype area at Ellis Bay on western Anticosti Island. The fauna appears at progressively higher levels in the formation in more eastern sections. For example, it appears within upper Member 1? at the Vauréal River section on east-central Anticosti Island and within upper Member 2? of the Salmon River section near the eastern end of the island (Figure 2). If the lithostratigraphic boundaries are considered as datum planes, then the first appearance of Fauna 13 may be slightly diachronous. McCracken and Barnes (1981a, p. 70) suggested that this distribution pattern probably was due to migration of *Gamachignathus* from offshore to nearshore environments. The difference in level of proliferation of the *Gamachignathus* species in the Ellis Bay Formation also may be partly a result of low-yielding samples near the base of the formation in central and eastern areas.

It is difficult to establish the degree of diachronism of the first appearance of Fauna 13, but it probably is not of great significance. It is just as reasonable to argue that the base of Fauna 13 interval represents a datum on Anticosti Island and that the lithic boundaries are diachronous. Whichever way the question is interpreted, it is clear that the first appearance of Fauna 13 is a significant event in the Anticosti Basin (see Figure 2). The nature and geographic extent of this event is not clear, but it may be related to an oceanic cooling event of sufficient magnitude to permit cratonward incursions of cool-water faunas. Because of the large scale of the regression near the end of the Ordovician, this incursion was limited to marginal areas of Laurentia.

CONCLUSIONS

The following conclusions are drawn in this report:

(1) A *Gamachignathus ensifer* First-Appearance Biohorizon is recognized by the first occurrence of *G. ensifer* 51.5 m above the base of the exposed part of the Vauréal Formation on Anticosti Island. This correlates with a level in the upper part of the Richmondian and with the upper part of Fauna 12. The *G. ensifer* Biohorizon is within the *Amplexograptus inuiti* graptolite Biozone.

(2) The *Gamachignathus ensifer* Biohorizon defines the lower limit of the *G. ensifer* Biozone; the upper boundary of the zone is the base of the *Ozarkodina hassi-O. oldhamensis* biointerval zone.

(3) Fauna 13, as defined by McCracken and Barnes (1981a), is an informal acme zone in which *Gamachignathus ensifer* is very abundant. Its recognition is restricted by the paucity of continuous sections with samples containing *Gamachignathus*.

(4) The Gamachian Stage is the uppermost stage of the Cincinnatian Series. Its base is coincident with the first appearance of Fauna 13, and it probably succeeds the Richmondian stage without overlap.

(5) The apparent diachroneity of the first appearance of Fauna 13 is temporally insignificant; the lithostratigraphic boundaries within the lower part of the Ellis Bay Formation probably are diachronous.

(6) *Gamachignathus* probably favored cool-water environments and was tolerant of substrate changes. The genus has North Atlantic Province ancestry and immigrated to areas marginal to Laurentia in latest Ordovician time in response to a global glacial cooling. It is unlikely that it will be found in strata of cratonic areas.

(7) The dramatic increase in relative abundance of elements of *Gamachignathus* that marks the base of the Fauna 13 interval and the Gamachian Stage was a major event in the Anticosti Basin that may be of global significance if it was related to glacial cooling.

(8) Elements of *Plectodina* appear to be absent from strata of latest Richmondian and Gamachian age. Their highest occurrence may be regarded as a last-appearance or extinction biohorizon.

(9) The first-appearance of *Pseudobelodina vulgaris ultima* may be a useful biohorizon in the upper Richmondian.

(10) The last-appearance of *Amorphognathus* may be a useful biostratigraphic biohorizon in the mid-Gamachian.

REFERENCES CITED

Bolton, T.E. 1972. Geological map and notes on the Ordovician and Silurian litho- and biostratigraphy, Anticosti Island, Quebec. Geol. Surv. Can Paper 71-19, 44 p.

Holland, C.H. 1985. Series and stages of the Silurian System. Episodes 8:101-104.

Lenz, A.C. and McCracken, A.D. 1982. The Ordovician-Silurian boundary, northern Canadian Cordillera: graptolite and conodont correlation. Can. J. Earth Sci. 19:1308-1322.

Lespérance, P.J. 1981. (ed.). International Union of Geological Sciences, Subcommission on Silurian Stratigraphy, Ordovician-Silurian Boundary Working Group. Field Meeting, Anticosti-Gaspé, Québec, 1981, Vol. II, Stratigraphy and Paleontology. Université de Montréal, 321 p.

__________ 1985. Faunal distributions across the Ordovician-Silurian Boundary, Anticosti Island and Percé, Québec, Canada. Can. J. Earth Sci. 22:838-849.

McCracken, A.D. and Barnes, C.R. 1981a. Conodont biostratigraphy and paleoecology of the Ellis Bay Formation, Anticosti Island, Québec, with special reference to Late Ordovician-Early Silurian chronostratigraphy and the systemic boundary. Geol. Surv. Can. Bull. 329(2):51-134.

__________ and __________ 1981b. Conodont biostratigraphy across the Ordovician-Silurian boundary, Ellis Bay Formation, Anticosti Island, Quebec. *In* Lespérance, P.J. (ed.), International Union of Geological Sciences, Subcommission on Silurian Stratigraphy, Ordovician-Silurian Boundary Working Group. Field Meeting, Anticosti-Gaspé, Québec, 1981, Vol. II, Stratigraphy and Paleontology. Université de Montréal, p. 61-69.

__________ and __________ 1982. Restudy of conodonts (Late Ordovician-Early Silurian) from the Edgewood Group, Clarksville, Missouri. Can. J. Earth Sci. 19:1474-1485.

__________, Nowlan, G.S., and Barnes, C.R. 1980. *Gamachignathus*, a new multielement conodont genus from the latest Ordovician, Anticosti Island, Québec. Geol. Surv. Can. Current Research, Part C, Paper 80-1C:103-112.

Mitchell, C.E. and Bergström, S.M. 1977. Three-dimensionally preserved Richmondian graptolites from southwestern Ohio and the graptolite correlation of the North American Upper Ordovican standard. Boll. Soc. Paleont. Italiana 16:257-270.

Nowlan, G.S. 1981. Late Ordovician-Early Silurian conodont biostratigraphy of the Gaspe Peninsula – a preliminary report. *In* Lespérance, P.J. (ed.), International Union of Geological Sciences, Subcommission on Silurian Stratigraphy, Ordovician-Silurian Boundary Working Group. Field Meeting, Anticosti-Gaspé, Québec, 1981, Vol. II, Stratigraphy and Paleontology. Université de Montréal, p. 257-291.

__________ 1983. Biostratigraphic, paleogeographic and tectonic implications of Late Ordovician conodonts from the Grog Brook Group, northwestern New Brunswick. Can. J. Earth Sci. 20:651-671.

__________ and Barnes, C.R. 1981. Late Ordovician conodonts from the Vauréal Formation, Anticosti Island, Québec. Geol. Surv. Can. Bull. 329(1):1-49.

__________, McCracken, A.D., and Chatterton, B.D.E. *In press.* Conodonts from Ordovician-Silurian boundary strata, Whittaker Formation, Mackenzie Mountains, Northwest Territories, Canada. Geol. Surv. Can. Bull. 373.

Orchard, M.J. 1980. Upper Ordovician conodonts from England and Wales. Geol. et Paleont. 14:9-44.

Petryk, A.A. 1981. Stratigraphy, sedimentology and Paleogeography of the Upper Ordovician-Lower Silurian of Anticosti Island, Québec. *In* Lespérance, P.J. (ed.), International Union of Geological Sciences, Subcommission on Silurian Stratigraphy, Ordovician-Silurian Boundary Working Group. Field Meeting, Anticosti-Gaspé, Québec, 1981, Vol. II, Stratigraphy and Paleontology. Université de Montréal, p. 11-39.

Riva, J. 1969. Middle and Upper Ordovician graptolite faunas of St. Lawrence Lowlands of Quebec, and of Anticosti Island. *In* Kay, G.M. (ed.), North Atlantic-Geology and Continental Drift. Amer. Assoc. Petrol. Geol. Mem. 12:513-556.

__________ and Petryk, A.A. 1981. Graptolites from the Upper Ordovician and Lower Silurian of Anticosti Island and the position of the Ordovician-Silurian boundary. *In* Lespérance, P.J. (ed.), International Union of Geological Sciences, Subcommission on Silurian Stratigraphy, Ordovician-Silurian Boundary Working Group. Field Meeting, Anticosti-Gaspé, Québec, 1981, Vol. II, Stratigraphy and Paleontology. Université de Montréal, p. 159-164.

Ross, R.J., Jr., Adler, F.J., Amsden, T.W., Bergström, D., Bergström, S.M., Carter, C., Churkin, M., Cressman, E.A., Derby, J.R., Dutro, J.T., Jr., Ethington, R.L., Finney, S.C., Fisher, D.W., Fisher, J.H., Harris, A.G., Hintze, L.F., Ketner, K.B., Kolata, D.L., Landing, E., Neuman, R.B., Sweet, W.C., Pojeta, J., Jr., Potter, A.W., Radner, E.K., Repetski, J.R., Shaver, R.H., Thompson, T.L., and Webers, G.F. 1982. The Ordovician System in the United States: correlation chart and explanatory notes. Int. Union Geol. Sci. Pub. 12, 73 p.

__________, Nolan, T.B., and Harris, A.G. 1979. The Upper Ordovician and Silurian Hanson Creek Formation of central Nevada. U.S. Geol. Surv. Prof. Paper 1126-C:C1-C22.

Savage, N.M. and Bassett, M.G. 1986. Caradoc-Ashgill conodont faunas from Wales and the Welsh Borderland. Palaeont. 28:679-713 (imprint 1985).

Schuchert, C. and Twenhofel, W.H. 1910. Ordovicic-Siluric section of the Mingan and Anticosti Islands, Gulf of St. Lawrence. Geol. Soc. Amer. Bull. 21:677-716.

Sweet, W.C. 1979. Late Ordovician conodonts and biostratigraphy of the western Midcontinent Province. Brigham Young Univ. Geol. Stud. 26(3):45-85.

__________ 1984. Graphic Correlation of upper Middle and Upper Ordovician rocks, North American Midcontinent Province, U.S.A. *In* Bruton, D.L. (ed.), Aspects of the Ordovician System. Palaeont. Cont. Univ. Oslo 295:23-35.

__________, Ethington, R.L., and Barnes, C.R. 1971. North American Middle and Upper Ordovician conodont faunas. *In* Sweet, W.C. and Bergström, S.M. (eds.), Symposium on Conodont Biostratigraphy. Geol. Soc. Amer. Mem. 127:163-193.

Twenhofel, W.H. 1928. Geology of Anticosti Island. Geol. Surv. Can. Mem. 154, 481 p.

Geological Survey of Canada Contribution Number 19786.

Relatively Chrono

Reuben J. Ross, Jr.
Department of Geology, Colorado School of Mines

"Look," said the mother watching her son's first military parade, "Johnny's the only one in step." The joke is so old it makes you groan. When we are told that correlations should be based primarily on graptolites, or on conodonts, or on any one taxon, we are told to follow Johnny.

Despite temptations like isotopic dating, magnetic reversals, seismic stratigraphy, and the reborn catastrophism, chronostratigraphy is biostratigraphic. This is not a necessarily narrow view; it is a practical view. Our greatest chronostratigraphic need is the establishment of all possible accurate cross-linkages between zonal schemes previously based on separate taxonomic groups of fossils. The sooner this need is met the sooner we shall achieve useful chronostratigraphic results.

The separation of time, time-rock and rock in stratigraphy is a useful endeavor to sharpen our thinking and discipline our observations. Beyond that it is a myth. Pure time is a philosophical concept having no place in geology, wherein all time is relative. Relative time separates geology intrinsically from all other scientific disciplines.

One might suppose that istopically derived ages stated in numbers of years are as close to true time as possible. But one soon discovers that the numbers depend on the analytical method used and the kind of mineral analyzed. Calibration of methods is required. That, itself, requires a return to the rock. If the rock is suitable for only one method, other rocks must be sampled and their relative ages determined geologically. In dealing with Phanerozoic rocks the number means little unless the rock from which the number was derived can be accurately dated by paleontology.

Series are rock units. A series may be defined as the rock deposited during the duration of a fossil zone or zones. At least one British Middle Ordovician series is so defined. But, it is probable that most series have been based on specified thicknesses of strata in specific geographic areas. All North American Ordovician series were defined in that manner. Each series has regional, facies, and paleoecologic significance too important to be discarded. In fact, trying to force the British classification into the North American scheme could be compared with the efforts of the ugly stepsisters to get into Cinderella's slipper.

Chronostratigraphic units, i.e., biostratigraphic units, based on multi-taxon fossil zones are the answer to the problem. If geochemical and geophysical methods will help, take advantage of them. Let each continent stick with Cinderella and let's not follow Johnny.

COMPILERS NOTE

A well-argued statement that "chronostratigraphy" is based on and is, simply, biostratigraphy may be found in:

Hancock, J.M. 1977. The historic development of concepts of biostratigraphic correlation. *In* Kauffman, E.G. and Hazel, J.E. (eds.), Concepts and Methods of Biostratigraphy. Dowden, Hutchinson and Ross, Inc., Stroudsburg, pp. 3-22.

Constraints of Brachiopod Zoogeography on Correlation in the Late Ordovician and Early Silurian of North America

Peter M. Sheehan
Department of Geology, Milwaukee Public Museum

ABSTRACT

The zoogeography of fossils limits the region in which a time-stratigraphic unit can be recognized. Stages are commonly limited to single realms or provinces simply because the organisms by which stages are recognized are not found outside of these zoogeographic regions. The Cincinnatian Series and its stages provides an example in which the time-stratigraphic units are confined to a realm located in the epicontinental seas of the North American Plate. The terminal Ordovician extinction eliminated the North American Realm, and the cosmopolitan faunas of the Early Silurian permit recognition of the Llandovery Series throughout most of the world, including North America.

INTRODUCTION

Historically, few brachiopod workers in North America have studied both Ordovician and Silurian faunas. This stems partly from the fact that few, if any, lineages continue across the systemic boundary in North America (Sheehan, 1975; Boucot, 1975). Thus, most studies have been confined to one side or the other of the boundary, and very few studies have followed faunas across the boundary. As a result, zoogeographic and biostratigraphic changes across the Ordovician-Silurian boundary are not well understood.

In addition, workers on either side of the boundary have used differing approaches to biogeography and biostratigraphy. The differing approaches, coupled with the biogeographic changes of the faunas, have made comparisons between published Ordovician and Silurian studies very difficult. For example, Williams (1969, 1973) found that Ordovician brachiopod provinces had markedly increasing numbers of pandemic genera during the Caradocian and Ashgillian Stages. Williams (1973, p. 264) viewed this change as "heralding the ubiquity of many Silurian brachiopod stocks." Sheehan (1982), on the other hand, found the change from endemism to cosmopolitanism at the systemic boundary was abrupt and attributed the change to an extinction event. Boucot (1975) summarized a long standing view that Silurian brachiopods were highly cosmopolitan. On the other hand, he and his associates (Wang and others, 1984) now have found considerable endemism in some Silurian faunas. Each of these studies has employed different methodologies in analyzing different data bases. What appears relatively cosmopolitan from an Ordovician point of view may be highly endemic when viewed in a Silurian context.

In an attempt to provide a common basis for comparison, Coorough (1986) compiled a data base of 220 published brachiopod faunal lists from most regions of the world. Using Johnson's (1971) Provinciality Index, she examined zoogeographic patterns in both the Late Ordovician and Early Silurian. Based on the distribution of genera, North American epicontinental seas were found to contain one of the most endemic faunas in the world during the Late Ordovician (Coorough, 1986; Sheehan and Coorough, 1986). The Provinciality Index (PI) for North American genera ranged from 0.16 to 0.42 when compared to eight other geographic regions. Only South China was more endemic at this time.

North American Silurian brachiopods were part of a cosmopolitan fauna (Boucot, 1975; Wang and others, 1984). The PI for North America ranged from 0.32 to 3.0 (Coorough, 1986). The low value was derived from a comparison with South China which is the only Silurian area with strong provincialism (Wang and others, 1984). The North American fauna had strong similarities with areas such as Armorica, Baltica and Siberia (PI=3.0, 2.3, 1.1, respectively) and was part of a single realm encompassing these regions.

Although provinces in the Ashgillian contained more pandemic genera than during the Caradocian (Williams 1973), Coorough (1986) has shown that a far more drastic change in zoogeographic patterns occurred at the end of the Ordovician. The terminal Ordovician extinction eliminated the Ordovician endemic brachiopod provinces and produced the cosmopolitan Silurian fauna as suggested by Sheehan (1975, 1982) and Lespérance and Sheehan (1976).

ZOOGEOGRAPHIC CONSTRAINTS ON CORRELATION

The strong provinciality of North American brachiopods prevents their use in recognizing the Cincinnatian Series and its stages beyond the margins of the North American realm (Williams, 1969). Baltica, Siberia, and South China also have endemic faunas, and each region has a unique biostratigraphic scheme. Brachiopods can be used to recognize the Welsh Ashgillian Series in some marginal areas of North America, for example Gaspe (Williams, 1969; Sheehan and Lesperance, 1979). Similar areas with open-ocean faunas have been found around the margins of the North American Plate in Maine (Neuman, 1968), Alaska (Ross and Dutro, 1966; Potter and others, 1980) and northern California (Potter and others, 1980).

During the Late Ordovician, Siberia was located to the north of the North American plate (Ziegler and others, 1977). Along the northern margin of the North American Plate in northern Greenland, brachiopods have strong affinities with Siberia (Hurst and Sheehan, 1982). Future study of these faunas will probably allow recognition of Siberian time-stratigraphic units in North Greenland. Thus, it will probably be possible to recognize time-stratigraphic subdivisions of other zoogeographic regions immediately adjacent to the North American Realm but still on the margins of the North American Plate.

The terminal Ordovician extinction was associated with a major glacial epoch (Berry and Boucot, 1973; Sheehan, 1973; Lenz, 1976). A world-wide glacioeustatic regression drained epicontinental seas and a combination of climatic changes and elimination of habitat caused a world-wide extinction event. Marked zoogeographic changes occurred during the glacial epoch. The record from the major lithospheric plates is poor at this time because the regression restricted sedimentation to marginal areas. The climate deteriorated as the glaciation intensified, and faunas that originated in the high-latitudes in North Africa and Southern Europe migrated toward the equator (Sheehan, 1979). The Hirnatian Stage is based on this invading fauna, which in North America has been recognized in Gaspe (Lespérance and Sheehan, 1981) and Maine (Neuman, 1968). At the same time, a fauna assigned to the Gamachian Stage by Twenhofel (1928) was present at the margins of the North American Province on Anticosti Island. During the Gamachian, glacio-eustatic regression had drained most epiric seas, producing a disconformity over much of North America. As a result, brachiopod faunas in the region of the North American Realm are poorly known at this time, but conodonts indicative of the Gamachian Stage have been reported from both the eastern and western margins of the North American Province (McCracken and Barnes, 1981; Ross and others, 1979).

Following the terminal Ordovician extinction, cosmopolitan faunas in North America allow the recognition of time-stratigraphic units that were first reported in the Welsh borderland. Only South China has a fauna so endemic that it will require a separate time-stratigraphic framework.

BRACHIOPOD TIME-STRATIGRAPHIC FRAMEWORK

Ideally, stage boundaries are based on the boundaries of zones (Berry, 1968). Because brachiopod faunas have not been studied in sufficient detail to erect zones, recognition of stages is accomplished by analyses of assemblages and a few individual lineages. For the foreseeable future, the primary subdivisions of both the Silurian and Ordovician will be based on graptolites and conodonts because the relative ranges of many species within these groups have been well established.

In North America, Silurian brachiopods have been used successfully to recognize the Llandovery Series and some of its subdivisions (Berry and Boucot, 1970; Boucot, 1975). Ranges of numerous brachiopod species have been tied to the biostratigraphic framework of graptolites and conodonts (Berry and Boucot, 1970; Boucot, 1975). However, a zonation based on the stratigraphic ranges of brachiopods is still in the distant future.

In stark contrast to the Silurian, stratigraphic ranges of North American Late Ordovician brachiopods are almost completely unknown. While many descriptive studies have been completed, no synthesis of relative ranges of taxa has been attempted. Brachiopods are of little use beyond establishing that faunas are generally Late Ordovician in age. It is virtually impossible to recognize the stages of the Cincinnatian based on brachiopod collections. For example, brachiopods that in Ohio and Kentucky are confined to the Richmondian rocks are present in Missouri in the Cape Limestone (Howe, 1986) with conodonts that suggest an early Maysvillian age (Ross and others, 1982). Until such time as the stratigraphic ranges of brachiopods are established in enough sections to allow relative ranges of brachiopod species to be determined, brachiopods will be of little use in refined biostratigraphic studies in the Upper Ordovician.

Part of the problem faced by Ordovician brachiopod workers is the provincial nature of the faunas. In the Silurian, studies of evolutionary sequences of *Eocoelia*, *Stricklandia*, and *Pentamerus* have been done in separate regions, but, because of the cosmopolitan nature of the faunas, these studies are applicable over broad regions of the world. In the Ordovician, when provinciality was stronger, each separate region requires its own biostratigraphic framework. Ordovician workers have not been negligent, they simply have a more complex mission than do Silurian workers. In the Silurian, North American correlation improves when new data is obtained in Baltica, the British Isles or any area within the huge cosmopolitan realm, but in the Ordovician, work done on North American faunas will be relevant only to North American biostratigraphy.

There is one particularly bright note for North American Ordovician biostratigraphy. The presence of both Siberian and Open Ocean Realm brachiopod faunas on the margin of the North American Plate may provide a unique opportunity to tie together the series and stages from all three realms.

ACKNOWLEDGMENTS

This work was supported by U.S. National Science Foundation Grant 81-15524.

REFERENCES CITED

Berry, W.B.N. 1968. Growth of a Prehistoric Time Scale Based on Organic Evolution. Freeman Co., San Francisco, 158 p.

____________ and Boucot, A.J. 1970. Correlation of North American Silurian rocks. Geol. Soc. Amer. Spec. Paper 102, 289 p.

____________ and ____________ 1973. Glacio-eustatic control of Late Ordovician-Early Silurian platform sedimentation and faunal changes. Geol.Soc. Amer. Bull. 84:275-284.

Boucot, A.J. 1975. Evolution and Extinction Rate Controls. Elsevier, Amsterdam, 427 p.

Coorough, P.J. 1986. Brachiopod provinciality in the Late Ordovician-Early Silurian. Master's thesis, University of Wisconsin-Milwaukee, 129 p.

Howe, H.J. 1986. A comparison of the brachiopod fauna in the Cape Limestone of Missouri with the standard Richmond fauna in the Ohio Valley. Geol. Soc. Amer. Abstracts with Programs 18:302.

Hurst, J.M. and Sheehan, P.M. 1982. Pentamerid brachiopod relationships between Siberia and east North Greenland in the Late Ordovician and Early Silurian. *In* Mamet, B. and Copeland, M.J. (eds.), Third North Amer. Paleont. Conv. Proc. 2:482.

Johnson, J.G. 1971. A quantitative approach to faunal province analysis. Amer. J. Sci. 270:257-280.

Lenz, A.C. 1976. Late Ordovician-Early Silurian glaciation and the Ordovician-Silurian boundary in the northern Canadian Cordillera. Geol. 4:313-317.

McCracken, A.D. and Barnes, C.R. 1981. Conodont biostratigraphy and paleoecology of the Ellis Bay Formation, Anticosti Island, Québec, with special reference to Late Ordovician-Early Silurian chronostratigraphy and the systemic boundary. Geol. Surv. Can. Bull. 329:51-134.

Neuman, R.B. 1968. Paleogeographic implications of Ordovician shelly fossils in the Magog belt of the northern Appalachian region. *In* Zen, E., White, W.S., Hadley, J.B., and Thompson, J.B. (eds.), Studies of Appalachian geology: northern and maritime. Interscience, New York, pp. 35-48.

Lespérance, P.J. and Sheehan, P.M. 1976. The Silurian – an interval with cosmopolitan faunas in the Appalachian-Caledonian Orogen. Geol. Soc. Amer. Abstracts with Programs 8:218.

___________ and Sheehan, P.M. 1981. Hirnantian fauna in and around Perce, Quebec. *In* Lespérance, P.J. (ed.), Subcommission on Silurian Stratigraphy, Ordovician-Silurian Boundary Working Group. Field Meeting, Anticosti-Gaspé, Québec, Vol. II, Stratigraphy and Paleontology, p. 231-245.

Potter, A.W., Gilbert, W.G., Ormiston, A.R., and Blodgett, R.B. 1980. Middle and Upper Ordovician brachiopods from Alaska and northern California and their paleogeographic implications. Geol. Soc. Amer. Abstracts with Programs 12:147.

Ross, R.J., Jr. and Dutro, J.T. 1966. Silicified Ordovician brachiopods from east-central Alaska. Smithsonian Misc. Coll. 149:1-22.

___________, Nolan, T.B., and Harris, A.G. 1979. The Upper Ordovician and Silurian Hanson Creek Formation of central Nevada. U.S. Geol. Surv. Prof. Paper 1126C, 22 p.

___________ and others. 1982. The Ordovician System of the United States, correlation chart and explanatory notes. Int. Union Geol. Sci. Pub. 12, 73 p.

Sheehan, P.M. 1973. The relation of Late Ordovician glaciation to the Ordovician-Silurian changeover in North American brachiopod faunas. Lethaia 6:147-154.

___________ 1975. Brachiopod synecology in a time of crisis (Late Ordovician-Early Silurian). Paleobiol. 1:205-212.

___________ 1979. Swedish Late Ordovician marine benthic assemblages and their bearing on brachiopod zoogeography. *In* Gray, J. and Boucot, A.J. (eds.), Historical biogeography, plate tectonics, and the changing environment. Oregon State Univ. Press, Corvallis, p. 61-73.

___________ 1982. Brachiopod macroevolution at the Ordovician-Silurian boundary. *In* Mamet, B. and Copeland, M.J. (eds.), Third North Amer. Paleont. Conv. Proc. 2:477-481.

___________ and Coorough, P.J. 1986. Brachiopod zoogeography at the terminal Ordovician extinction (abstract). North American Paleontological Convention IV, Boulder, Colorado.

___________ and Lespérance, P.J. 1979. Late Ordovician (Ashgillian) brachiopods from the Percé region of Québec. J. Paleont. 53:950-967.

Twenhofel, W.H. 1928. Geology of Anticosti Island. Geol. Surv. Can. Mem. 154, 481 p.

Wang, W., Boucot, A.J., Rong, J.-y., and Yang, X.-c. 1984. Silurian and Devonian biogeography of China. Geol. Soc. Amer. Bull. 95:265-279.

Williams, A. 1969. Ordovician of British Isles. Amer. Assoc. Petrol. Geol. Mem. 12:236-264.

___________ 1973. Distribution of brachiopod assemblages in relation to Ordovician Palaeogeography. Palaeont. Assoc. Spec. Papers Paleontol. 12:241-269.

Ziegler, A.M., Hansen, K.S., Johnson, M.E., Kelly, M.A., Scotese, C.R., and Van der Voo, R. 1977. Silurian continental distributions, paleogeography, climatology, and biogeography. Tectonophys. 40:13-51.

Mohawkian and Cincinnatian Chronostratigraphy

Walter C. Sweet
Department of Geology and Mineralogy, The Ohio State University

ABSTRACT

Post-Whiterockian chronostratigraphic units are reviewed in a high-resolution framework provided by conodont-based graphic correlation of 70 sections in North America. It is recommended that boundary stratotypes for all post-Whiterockian through pre-Gamachian stadial units be sited in the standard reference section of the graphic network at levels in that section to which defining criteria project. It is further recommended that surface sections conforming closely to the intervals bounded in the standard reference section be established as regional reference sections.

INTRODUCTION

Despite the fact that strata referable to the Mohawkian and Cincinnatian Series (*sensu* Ross and others, 1982) are widespread and fossiliferous, have been the subjects of hundreds of stratigraphic studies, and may represent as much as 30 my of time, it is still customary to discuss the history they represent within a framework divided variously into just eight stages, seven informal conodont-faunal intervals, three formally defined conodont zones, or four to eight graptolite zones. Although the three formal Mohawkian and Cincinnatian conodont zones proposed by Bergström (1971) are based on a documented evolutionary succession, no combination of units from any of the other faunal groups forms a chronostratigraphic scale that is unambiguously free of gap or overlap. In addition, a scale capable of distinguishing no more than eight units, of unknown but demonstrably unequal scope can hardly be said to have very great resolving power.

Conodonts are abundantly represented in Mohawkian and Cincinnatian rocks in North America, and Sweet (1984a) summarized results of an attempt to use their distribution as the framework for a high-resolution chronostratigraphy for the late Middle and Late Ordovician. That framework was compiled graphically by repeated pairwise correlation and recorrelation of 61 carefully measured stratigraphic sections within which the levels of first and last occurrence of more than 100 species had been precisely located. The Mohawkian-Cincinnatian part of the composite section described in that report is divisible into 80 resolvable chronostratigraphic units and thus provides 10 to almost 27 times the resolution of other chronostratigraphic schemes.

Since 1984, the geographic area to which the framework is applicable has been expanded through compilation of information from 10 additional sections. None of this information has required significant adjustment of the previously described scheme (Sweet, 1984a). However, there have been revisions of the interpretations of the Lay School and Nashville Basin sections which were important contributors to the framework described by Sweet (1984a). Those adjustments, which are described briefly in an appendix to this report, provoke minor changes in parts of the composite standard section of the 1984a report but do not influence the resolution of the chronostratigraphic scale based on it. Thus, it may be concluded that the conodont-based graphically compiled scale presented in abbreviated form by Sweet (1984a) is reasonably stable and that it may be used as the basis for meaningful comments on late Middle and Late Ordovician chronostratigraphy in North America.

CONODONT-BASED COMPOSITE STANDARD

Technique

Graphic compilation and recorrelation of 71 individual sections using procedures described by Shaw (1964), Miller (1977) and Sweet (1979b) result in a series of equations that make it possible to relate the distribution of the biologic events (i.e., first and last occurrences, acmes) and the positions of the stratigraphic boundaries in those sections to a standard reference section (SRS). A composite standard (CS) is a summary, in chart, list or tabular form, of stratigraphic and/or biologic information stated or drawn in terms of the dimensions of the standard reference section.

Figure 1 depicts in chart form the positions of selected stratigraphic boundaries in Sweet's (1984a) conodont-based CS with modifications described in the appendix. The vertical dimension of Figure 1 is slightly more than the measured thickness of the SRS, a 477 m sequence of fossiliferous Middle and Upper Ordovican rock in the Cincinnati region of Kentucky, Ohio and Indiana. The base of the SRS is the unconformity between rocks of the Lower Ordovician Knox Group and the Middle Ordovician High Bridge Group in a core taken near Minerva, Kentucky (Votaw, 1971; Sweet, Harper and Zlatkin, 1974); the top of the SRS is the unconformity that separates Cincinnatian and Lower Silurian strata in a core taken near New Point, Indiana (Bergström and Sweet, 1966; Sweet, 1979a). There is substantial overlap between the two components of the SRS, and they assemble graphically with great reliability. However, it is nevertheless important to note that the SRS is itself composite. Aside from commissioning the drilling of a continuous core from the top of the Ordovician to the base of the Middle Ordovician, there currently is no way to avoid this problem.

The base of the SRS has been assigned the arbitrary value of 800 m, rather than 0, which should enable eventual addition of pre-Mohawkian information without revising values stated in 1984a or in this report. Thus, in Figure 1 the base of the Mohawkian is at 809, for the lowest occurrence of *Prioniodus* (*Baltoniodus*) *gerdae* Bergström in any section now included in the CS projects to a level 9 m above the base of the SRS. Similarly, the base of the Edenian Stage (and Cincinnatian Series) is set at 1063 m because that is the position in the SRS of the base of the Kope Formation determined by graphic correlation of the SRS and the Moffett Road Section (Sweet, 1984b) of Kenton County, Kentucky.

Resolution

In 1984 and in the introduction to this report it was noted that the conodont-based Mohawkian-Cincinnatian CS may be divided into 80 chronostratigraphic divisions (=standard time units, or STUs, of Shaw, 1964) each, at least conceptually, of the same length. These divisions are anchored in successive 6 m divisions of the SRS. The decision to regard a 6 m unit as the thinnest interval with equivalents that could be recognized with confidence in component sections of the network was based on the observation that, in the most weakly controlled sections, parallel lines intersected the X-axis at 6 m intervals and bounded arrays which fit the lines of correlation. Thus, it could not be argued that, with respect to those sections, events recorded by features of the CS less than 6 m apart were, in fact, separate. Consequently, because maximum array width was 6 m in the 61 sections compiled in 1984, the 477 m SRS was divided into 79.5 divisions. This value (expanded to 80 to include a thin sequence of Late Ordovician rock in Wyoming that projects above the SRS) is thus the stated resolving power of the CS. Increased resolution will require more closely spaced collections, information from other fossil groups, or elimination of sections in which array width is wide because of poor collections or collection failure, poor exposure, faulty measurement, indifferent taxonomy, or poorly controlled, or careless and incomplete reporting of ranges.

CHRONOSTRATIGRAPHIC UNITS

Duration

If each of the 80 divisions of the SRS represents an interval of approximately the same length, and if the Mohawkian and Cincinnatian together were approximately 30 my long, then each division of the SRS represents about 375,000 years. From comments in a previous paragraph dealing with resolution, it follows that, at the present level of resolution, events or boundaries that are not separated in the SRS by more than 6 m in their actual or projected positions cannot be said to be of different ages, although they might differ in actual age from place to place within the network by as much as 375,000 years – or by whatever the value of a standard time unit turns out to be. This must be kept in mind in discussing chronostratigraphic units whose boundaries are taken by definition to be conceptual surfaces of synchroneity.

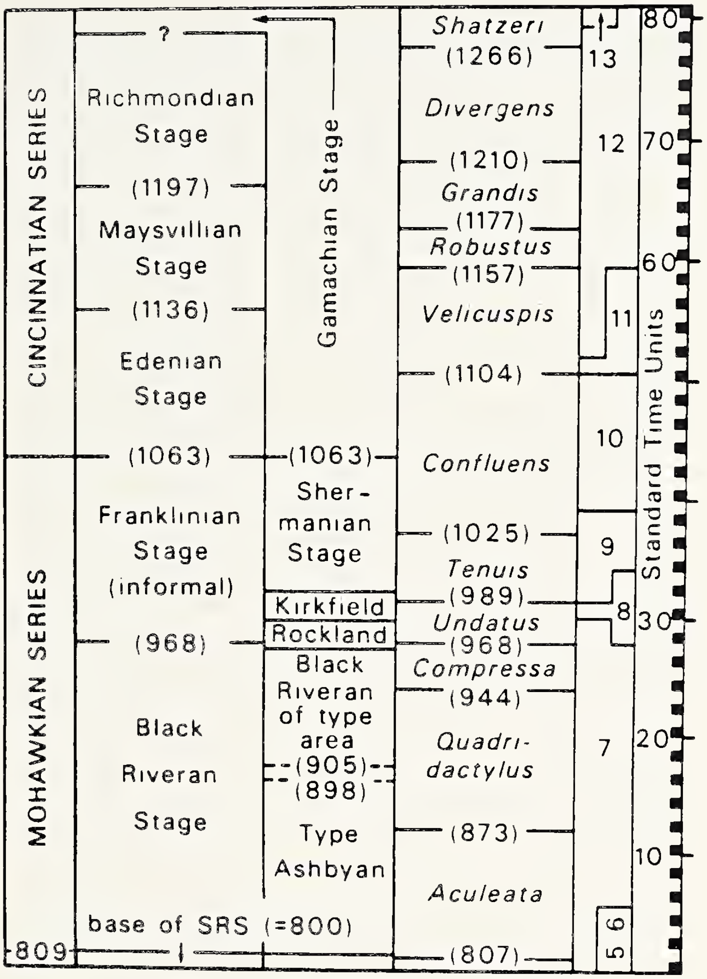


Figure 1 The arrangement of series, stages, chronozones, faunal intervals, and standard time units indicated by conodont-based graphic correlation. Numbers on lines are positions (in meters) of the boundaries indicated in the Composite Standard Section. Vertical scale is that of the Standard Reference Section.

Series

In Figure 1, Ross and others (1982) are followed in dividing the post-Whiterockian Ordovician of North America into two series, Mohawkian and Cincinnatian.

I am not troubled by the fact that Bergström (in Ross and others, 1982) proposes to set the base of the former at the lower limit of a conodont-based biostratigraphic unit (the *Prioniodus* [*Baltoniodus*] *gerdae* Subzone) whereas the base of the latter has been fixed for the last 113 years at the base of the Kope Formation (or Eden Shales) in the city of Cincinnati, Ohio. Both levels may be projected into the SRS with adequate control of equivalent quality, and both may be recognized, within current limits of resolution, in the other 70 sections that are now parts of the graphically controlled, conodont-based CS.

On the subject of serial boundaries, it is noted only that there is some conflict between different discussions of the basal Mohawkian (or basal Black Riveran) boundary in Ross and others (1982). At one place it is suggested, in effect, that the "golden spike" be driven in at the base of the Elway Formation, in Hogskin Valley, Tennessee; but, in another, it is proposed that the boundary be placed at the level of first occurrence of the conodont *Prioniodus* (*Baltoniodus*) *gerdae* Bergström. These two levels (base of Elway; first occurrence of *P. gerdae*) are now separated in the CS by only 1 m (see Figure 2). These levels lie within the current resolution limits of the CS and are approximately equivalent. Carnes (1975) was unable to identify typical representatives of *P. gerdae* in the Lay School section in Hogskin Valley, however, and it would obviously be risky to peg the base of the Mohawkian to the base of the Elway there if the intention is to recognize that important datum elsewhere at the level of first occurrence of *P. gerdae*.

It is here recommended that the base of the Mohawkian be placed at the projected level of first occurrence of *Prioniodus* (*Baltoniodus*) *gerdae* (that is, at the base of the *gerdae* Subzone) in the Mohawkian-Cincinnatian SRS identified in this and the 1984a report. That level is now 809 m, or 9 m above the base of the High Bridge Group in Cominco-American core C-38, drilled near Minerva, Kentucky, but stored permanently in the Micropaleontological Laboratory of The Ohio State University. The base of the Elway in the Lay School section of Hogskin Valley, Tennessee (Carnes, 1975), might be designated a boundary parastratotype, or regional reference level, but without official status.

Stages

In Figure 1, the Mohawkian Series is here divided into two stages, the older named "Black Riveran," the younger, provisionally designated "Franklinian." For the reasons mentioned by Ross and Bergström (in Ross and others, 1982) the Black Riveran Stage is substantially more inclusive than an interval of that name based on any extant section in the Black River Valley of northern New York. In 1982, however, the lower boundary of the Black Riveran Stage was set at the level of the first occurrence of *Prioniodus* (*B.*) *gerdae* and the Hogskin Valley of Tennessee was mentioned as a potential stratotype. It might be argued that essentially doubling the stratigraphic content of a stage changes it so drastically as to require a new name and type section. It is doubted, however, that the action recommended by Ross and Bergström will cause any difficulty. Lowering the base of the Black Riveran to the suggested level does little more than close a gap long known to exist between the Chazyan and Black Riveran stages by adding the time represented by that gap to the Black Riveran Stage. It is of some interest to note that the interval tacked onto the Black Riveran is very nearly the one for which Cooper (1956) proposed the term Ashbyan Stage. For example, in Figure 2, the top of the type Ashbyan in the Lay School section of Hogskin Valley, Tennessee (Carnes, 1975), projects to the 898 m level in the SRS whereas the oldest rocks included in the type Black Riveran of New York project (without control) to about 905 m. This suggests that the interval identified as Black Riveran by

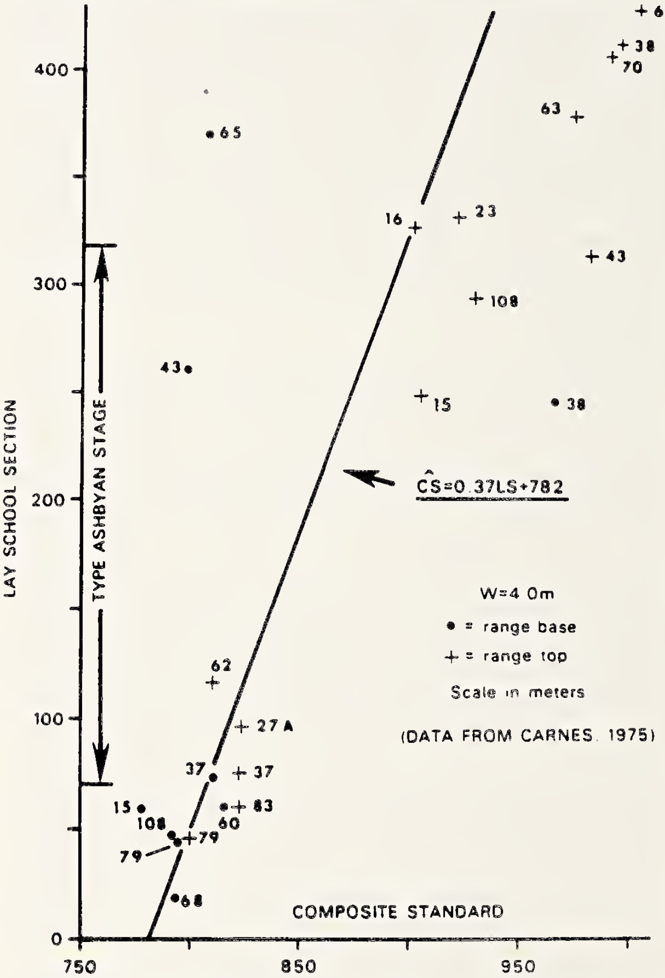


Figure 2 **Graphic correlation of section at Lay School, northeastern Tennessee, with Composite Standard Section. Names of species listed by number in Appendix to Sweet (1984a).**

Ross and others (1982) could be divided into Ashbyan and Black Riveran stages at about the 905 m level in the SRS. Alternatively, the Black Riveran might be divided into two substages, for the earlier of which "Ashbyan" might be an appropriate name. Although I have no strong feelings on this matter, I point out that recognition of Ashbyan and Black Riveran stages would have the advantage of dividing this part of the Ordovician into stadial units of about the same length as those recognized in later parts of the Ordovician.

In Figure 1, the Black Riveran is succeeded by a stage informally termed Franklinian. This is approximately the interval commonly identified as the Trentonian, divided into Rocklandian, Kirkfieldian and Shermanian stages. In 1971, Bergström and Sweet demonstrated that the Trentonian, based on the Trenton Group exposed at Trenton Falls, New York, completely overlaps the early Cincinnatian Edenian Stage and projects into the overlying Maysvillian. Graphic correlation, involving additional information, confirms conclusions we expressed qualitatively in 1971 (Sweet, 1984a). Thus, it is no longer appropriate to use the term Trentonian for a pre-Cincinnatian Stage and it is recommended that it be abandoned in any future discussion of Middle Ordovician chronostratigraphy.

As indicated in Figure 1, Rocklandian, Kirkfieldian and Shermanian are terms for stratigraphic intervals of greatly different extent. They are not very useful as biostratigraphic divisions and they certainly do not compare in scope with the expanded Black Riveran Stage of Ross and others (1982), or even with the Ashbyan, which is included here within the Black Riveran. Thus, it is recommended that Rocklandian, Kirkfieldian and Shermanian be abandoned as names for formal divisions of the post-Black River pre-Cincinnatian interval and that a single name be substituted for this interval. It is here suggested that the name Franklinian, from Franklin County, Kentucky, be adopted, that its lower boundary be drawn at the level of first occurrence in the SRS of the conodont *Phragmodus undatus* Branson and Mehl, and that its upper boundary be the base of the superjacent Edenian Stage, which also defines the base of the Late Ordovician Cincinnatian Series. Conodont distribution within this interval has been described in detail by Bergström and Sweet (1966), Schopf (1966), Webers (1966), and Sweet (1979a). *Phragmodus undatus* makes its debut in the SRS at 968 m, which is 2 m higher than the projected level of the base of the Rocklandian. For reasons mentioned earlier, however, this difference is well within a 6 m standard time unit, so it can not be argued that the two levels really are different.

The long, well-exposed sequence of rock between the base of the Curdsville Limestone Member and the top of the Brannon Member of the Lexington Limestone in roadcuts on the north and south sides of U.S. I-64 just east of the Kentucky River in southern Franklin County, Kentucky (Pomeroy, 1968), would be a suitable and readily accessible regional reference section for all but the lower 27 m of the Franklinian Stage. The succession between the base of the Glenwood Shale and the Base of the Stewartville Formation, in southeastern Minnesota (Webers, 1966), would also be suitable as a regional reference section for a Franklinian Stage but probably would have to be pieced together from sections at several localities.

In Figure 1, the Cincinnatian Series is divided into Edenian, Maysvillian, Richmondian and Gamachian stages. The first three of these have their type sections in the Cincinnati Region at localities indicated by Orton in 1873. Because the base of the Eden Shales (now the Kope Formation) is not exposed in the city of Cincinnati, it is recommended that the Edenian (and Cincinnatian) base be the projected level in the SRS of the base of the Kope Formation in the Moffett Road section, Kenton County, Kentucky (Sweet, 1984b). The level of the base of the Kope is used in that section (1063 m) in Figure 1 but it is pointed out that the Moffett Road section itself will not be a suitable reference section for this boundary because it is no longer very well exposed. Several other possible ancillary reference sections could be suggested but it is better to wait until conclusions on the correlation of sections at some 30 localities in the Cincinnati region have been published.

The base of the Maysvillian Stage is the base of the Fairview Formation (Orton's "Hill Quarry Beds") in a section that was once well exposed along Clifton Avenue, in Cincinnati. The name of the stage, of course, comes from the city of Maysville, Kentucky, some 75 miles southeast of Cincinnati. In the vicinity of Maysville, however, the base of the Fairview Formation projects to a level well above the base of the Maysvillian Stage as defined in Cincinnati. The base of the Richmondian Stage was set by Orton (1873) at the top of the "*Orthis lynx*" (=*Platystrophia ponderosa*) beds in an exposure along the Lebanon-Wilmington Road where it crosses the Little Miami River some 25 miles north of Cincinnati, Ohio. Orton originally used the term "Lebanon Beds" for the rocks between the "*Orthis lynx*" beds and the overlying Silurian Clinton (=Brassfield) Limestone. Winchell and Ulrich (1897) pointed out that "Lebanon" was preoccupied and proposed "Richmond" as a substitute, without, however, changing the stratotype. A single surface locality that would serve as a suitable reference section for the Richmondian Stage is not known. Combinations will not be suggested until details on correlation within the Cincinnati Region have been published.

In 1979a Sweet summarized conodont-distributional evidence in the Cincinnati region that bears on recognition and correlation of Cincinnatian stadial boundaries. If formal recommendation is necessary, it is suggested that those boundaries be established at the 1063 m, 1136 m, and 1197 m levels in the SRS, where they are drawn in Figure 1 of this report.

The youngest Cincinnatian stage of Figure 1, the Gamachian, is a problem. The stage was based originally on the Ellis Bay Formation of Anticosti Island, Quebec (Schuchert and Twenhofel, 1910), but McCracken and Barnes (1981) now recommend that only rocks from the base of Member 1 to a level a few meters above the base of Member 6 of the Ellis Bay be included. Presumably, however, the recent decision to peg the base of the Silurian at the base of the *acuminatus* graptolite zone will require upward adjustment of the upper boundary of the type Gamachian.

Most authors regard the Gamachian as post-Richmondian, but pre-Silurian, although it has not been possible to relate the richly fossiliferous Anticosti strata to those of the type Richmondian with any precision. A restudy of the conodont faunas described in detail by Nowlan and Barnes (1981) and McCracken and Barnes (1981) should help settle obvious taxonomic differences and may aid in relating the Anticosti sections to others in the graphic network. That review has not been made. Thus, for the present, the base of the Gamachian Stage (and, by default, the top of the Richmondian) is set at the base of the Ellis Bay Formation, on Anticosti Island, Quebec. Preliminary and quite tentative graphic correlation utilizing conodont distributional information from Nowlan and Barnes (1981) suggest that the youngest Richmondian strata in the Cincinnati region may fall within a single STU of the projected position of the base of the Ellis Bay Formation. But this needs confirmation that can be provided only by reconsideration of the Ellis Bay conodont collections and agreement on identification of specimens.

Conodont Chronozones

In Ross and others (1982) and again in 1984a, Sweet outlined the extent and briefly described the criteria for recognizing 11 conodont chronozones in the post-Whiterockian Ordovician of North America. These were not proposed as substitutes for the much higher resolution provided by the 80 STU's of the graphically assembled CS but were regarded as a convenient way of avoiding continued, but inappropriate use of the numbered faunal units described in 1971 by Sweet, Ethington and Barnes. The extent of both the 12 numbered faunal units and the 11 chronozones also is shown in Figure 1. A thirteenth faunal unit has been employed in discussing the conodont fauna and correlation of the Ellis Bay Formation of Anticosti Island. Its approximate extent also is shown in Figure 1 even though there is some ambiguity in the definition of this unit.

Bases of the conodont chronozones of Figure 1 are the SRS levels at which the nominate species of the zone make their first appearances. Those levels may change, of course, as additional information on the ranges of the nominate species becomes available or as ideas on correlation of various sections change. For example, recorrelation of the Lay School section, described in the appendix, results in moving the base of the *quadridactylus* chronozone down by 33 m in the SRS. Reinterpretation of the collections from the Nashville Basin section results in raising the level of first occurrence of *Belodina compressa* by 17 m in the SRS and the base of the *compressa* zone by that much in the CS. Neither change, however, requires any redefinition of the chronozones involved, only a change in the position of their basal boundary in the CS.

SUMMARY OF RECOMMENDATIONS

Based on relations clearly shown in the conodont-controlled CS summarized in Figure 1 of this report, the division of the post-Whiterockian Ordovician of North America into Mohawkian and Cincinnatian Series is accepted. The former is readily divisible into chronostratigraphic units termed "Black Riveran" and (informally) "Franklinian" stages; the latter into stages termed Edenian, Maysvillian, Richmondian and Gamachian. It is recommended that the base of the Mohawkian Series, Black Riveran Stage and Ashbyan Substage be placed at the projected level of first occurrence of *Prioniodus (Baltoniodus) gerdae* Bergstrom, which currently is 9 m above the base of the composite SRS that serves as the basis for the CS summarized in Figure 1. It is further recommended that the base of the upper Mohawkian stage, for which the name "Franklinian" is suggested, be placed at the level of first occurrence in the SRS of *Phragmodus undatus* Branson and Mehl, that the bases of the Edenian, Maysvillian and Richmondian stages be fixed formally at the levels in the SRS to which their bases project as a result of graphic correlation of their stratotypes, and that the base of the youngest Cincinnatian stage, the Gamachian (and by default the top of the subjacent Richmondian Stage), be set at the base of the Ellis Bay Formation on Anticosti Island, Quebec.

It is also recommended, for purposes of establishing additional collections, making paleomagnetic determinations, etc., that a series of regional reference sections be designated. Preferences for all such sections have not been indicated but two were mentioned that could serve for the informally designated Franklinian Stage.

If adopted, these recommendations would make the SRS chosen in 1984a and redescribed here the official reference section for the boundaries between all post-Whiterockian chronostratigraphic units of the North American Ordovician except the Gamachian Stage. Because the SRS is a composite of two long drill cores, both kept in the laboratory in Columbus, Ohio, adoption of these recommendations would also have the effect of making The Ohio State University custodian of the objective base for boundary stratotypes of all post-Whiterockian pre-Gamachian chronostratigraphic units, just as the Bureau of Standards in Washington is custodian of the reference yard. A few years ago there might have been reservations about making such a boldly acquisitive proposal. Now, it is noted that taxonomic and/or geographic chauvinism was evidently the basis for siting the stratotype of the Ordovician-Silurian boundary in otherwise almost barren graptolite shales in Scotland. Thus, there ought not to be serious objection on such ground to this proposal which differs in having both scientific and archival merit.

ACKNOWLEDGMENTS

I am grateful to S.M Bergstöm for his thoughtful reading of, and comments on, an earlier version of this manuscript. K. Tyler drafted the figures.

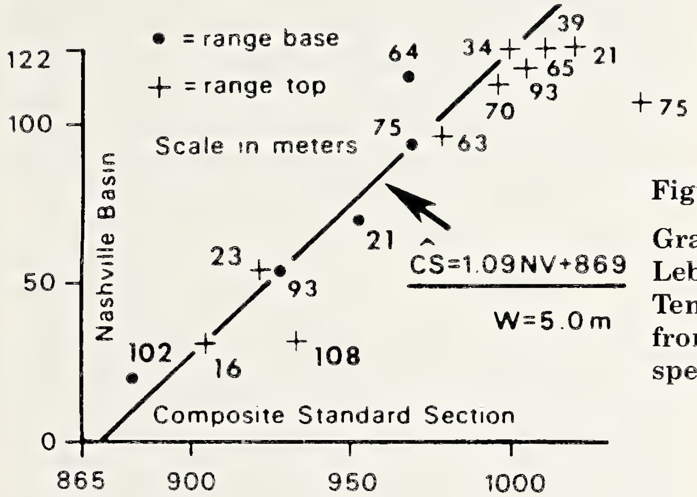


Figure 3

Graphic correlation of upper Murfreesboro, Pierce, Ridley, Lebanon and Carters formations of the Nashville Basin, Tennessee, with the Composite Standard Section. Data from Votaw (1971), sections 70VJ, VK, VL and VM. Names of species listed by number in Appendix to Sweet (1984a).

REFERENCES CITED

Bergström, S.M. 1971. Conodont biostratigraphy of the Middle and Upper Ordovician of Europe and eastern North America. Geol. Soc. Amer. Mem. 127:83-161.

__________ and Sweet, W.C. 1966. Conodonts from the Lexington Limestone (Middle Ordovician) of Kentucky and its lateral equivalents in Ohio and Indiana. Bull. Amer. Paleont. 50(229):271-424.

Carnes, J.B. 1975. Conodont biostratigraphy in the lower Middle Ordovician of the western Appalachian thrust-belts in northeastern Tennessee. Doctoral dissertation, Ohio State Univ., 291 pp.

Cooper, G.A. 1956. Chazyan and related brachiopods. Smithsonian Misc. Coll. 127, 1245 p.

McCracken, A.D. and Barnes, C.R. 1981. Conodont biostratigraphy and paleoecology of the Ellis Bay Formation, Anticosti Island, Quebec, with special reference to Late Ordovician-Early Silurian chronostratigraphy and the systemic boundary. Geol. Surv. Can. Bull. 329(2):51-134.

Miller, F.X. 1977. The graphic correlation method in biostratigraphy. *In* Kauffman, E.G. and Hazel, J.E. (eds.), Concepts and Methods of Biostratigraphy. Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania, p. 165-186.

Nowlan, G.S. and Barnes, C.R. 1981. Late Ordovician conodonts from the Vaureal Formation, Anticosti Island, Quebec. Geol. Surv. Can. Bull. 329:1-49.

Orton, E. 1873. Report on the third geological district; geology of the Cincinnati Group; Hamilton, Clermont, Clarke counties. Ohio Geol. Surv. Rept. 1:365-480.

Pomeroy, J.S. 1968. Geologic map of the Frankfort East Quadrangle, Franklin and Woodford counties, Kentucky. U.S. Geol. Surv. Geol. Quad. Map GQ-707.

Ross, R.J., Jr. and others. 1982. The Ordovician System in the United States, correlation chart and explanatory notes. Int. Union Geol. Sci. Pub. 12, 73 p.

Schopf, T.J.M. 1966. Conodonts of the Trenton Group (Ordovician) in New York, southern Ontario, and Quebec. New York State Mus. Bull. 405, 105 p.

Schuchert, C. and Twenhofel, W.H. 1910. Ordovicic-Siluric section of the Mingan and Anticosti Islands, Gulf of St. Lawrence. Geol. Soc. Amer. Bull. 21:677-716.

Shaw, A.B. 1964. Time in Stratigraphy. McGraw-Hill, New York, 365 p.

Sweet, W.C. 1979a. Conodonts and conodont biostratigraphy of post-Tyrone Ordovician rocks of the Cincinnati Region. U.S. Geol. Surv. Prof. Paper 1066-G:1-26.

__________ 1979b. Late Ordovician conodonts and biostratigraphy of the western Midcontinent Province. Brigham Young Univ. Geol. Stud. 26(3):45-86.

___________ 1984a. Graphic correlation of upper Middle and Upper Ordovician rocks, North American Midcontinent Province, U.S.A. *In* Bruton, D.L. (ed.), Aspects of the Ordovician System. Univ. Oslo Paleont. Cont. 294, pp. 23-35.

___________ 1984b. Conodonts, conodont biostratigraphy and correlation of the Moffett Road section (Middle and Upper Ordovician), Kenton county, Kentucky. U.S. Geol. Surv. Open-File Rept. 84-270, 18 p.

___________ and Bergström, S.M. 1971. The American Upper Ordovician Standard. XIII: a revised time-stratigraphic classification of North American upper Middle and Upper Ordovician rocks. Geol. Soc. Amer. Bull. 82:613-628.

___________, Ethington, R.L., and Barnes, C.R. 1971. North American Middle and Upper Ordovician conodont faunas. Geol. Soc. Amer. Mem. 127:163-193.

___________, Harper, H., Jr. and Zlatkin, D. 1974. The American Upper Ordovician Standard. XIX: a Middle and Upper Ordovician reference section for the eastern Cincinnati region. Ohio J. Sci. 74(1):47-54.

Votaw, R.R. 1971. Conodont biostratigraphy of the Black River Group (Middle Ordovician) and equivalent rocks of the eastern Midcontinent, North America. Doctoral dissertation, Ohio State Univ., 170 pp.

Webers, G.F. 1966. The Middle and Upper Ordovician conodont faunas of Minnesota. Minn. Geol. Surv. Spec. Pub. SP-4, 123 p.

Winchell, N.H. and Ulrich, E.O. 1897. The Lower Silurian deposits of the upper Mississippi province; a correlation of strata with those in the Cincinnati, Tennessee, New York, and Canadian provinces, and the stratigraphic and geographic distribution of fossils. Minn. Geol. Surv. Paleont. 3, part 2, pp. 83-128.

APPENDIX

Lay School Section (Figure 2)

Carnes (1975) has range data for 34 conodont species in this important section, which is 432 m thick and is in the western Appalachian thrust belt, in Hogskin Valley, Grainger County, Tennessee. Elway-Eidson and Hogskin beds, 70-318 m above the base of the section, are the stratotype of Cooper's (1956) Ashbyan Stage.

In 1984a, a line of correlation was fitted with an equation, CS=0.54LS+772 to the following array of points (see Figure 2): B79, B37, T27A, T15, T108, T70, and T38. Bergström (personal communication, 1985) pointed out, however, that that correlation projects units in the upper part of the Lay School section much too high statigraphically. Consequently, it is here suggested that a line joining T79 and T16 (and very nearly intersecting B37) also represents a plausible interpretation of the relationship between the Lay School and Composite Standard sections. That line is less well controlled than the one fit in the 1984a report, but there are also fewer anomalously high or low values to account for in the interpretation of Figure 2.

The Composite Standard section has been adjusted to account for new range values that result from recorrelation of the Lay School section.

Nashville Basin (Figure 3)

In the 1984a report, a line of correlation with the equation, CS=1.15N+867, was fit to the array T15, B93, B75, T63, T70, and T65 and used to incorporate range data from the Nashville Basin Ordovician sections into the Composite Standard Section. Data were all derived from Votaw (1971).

Recorrelation of the Lay School Section resulted in substantial changes in the CS values of T15 and T16 and prompted reconsideration of the 1984a correlation of the Nashville Basin section in which both events are recorded. That reconsideration also led to a restudy of the material on which the anomalously low first occurrence of *Belodina compressa* (species no. 21) was based.

As indicated in Figure 3, it is now suggested that a line of correlation with the equation, CS=1.09NV+869, represents a better correlation of the Nashville Basin Ordovician section studied by Votaw (1971). That line is fit to the array T16, T23, B93, B75, T63, and T34. W is 5, or slightly better than the value of 6 obtained in 1984a.

The principal result of this slight adjustment in correlation of the Nashville Basin section is a substantial rise in the CS of the level of first occurrence of *Belodina compressa* (species 21) and of the base of the *compressa* chronozone, formerly at 927 m in the CS (Sweet, 1984a), now at 944 m (Figure 1). The range top of species 15 (*Appalachignathus delicatulus*) is still anomalously high in the Nashville Basin Ordovician; but the specimens on which that high range is based were studied at the time the species was established (Votaw is one of its authors), hence are not likely to have been misidentified.

Lower Ordovician Chronostratigraphy and Graptolite Biostratigraphy in Eastern Canada

---

S. Henry Williams
Department of Earth Sciences, Memorial University of Newfoundland

ABSTRACT

Ordovician stages of the Australian chronostratigraphical scheme have been assigned to three series, namely the Lower, Middle and Upper Ordovician. Graptolite biozones should be distinguished clearly from these chronostratigraphic stages while the usage of chronozones for biostratigraphic correlation should be discontinued. Neither the biostratigraphic nor chronostratigraphic schemes should be forced onto complete graptolitic successions in North America and new biostratigraphic subdivisions should be defined for these North American sequences.

North American Ordovician chronostratigraphy is based on shallow-water conodont and shelly faunas and is not applicable to deep-water successions that yield mostly graptolite and conodont faunas. Furthermore, it is somewhat imprecise and not easily applicable to strata of similar age on other continents. British chronostratigraphic divisions could prove more suitable for deeper water successions of the Lower Ordovician if defined precisely and subdivided within a continuous, richly fossiliferous sequence, such as that of the Cow Head Group, western Newfoundland.

The commonly used distinction of Lower-Middle Ordovician graptolite assemblages into "Pacific" and "Atlantic" faunal provinces does not represent true provincialism. Actual variation is controlled by original paleoecological factors that differentiate relatively shallow, restricted shelf faunas from deeper, open ocean assemblages and is an artifact of bibliographic usage.

INTRODUCTION

Much current debate on Lower-Middle Ordovician graptolitic biostratigraphy and relevant chronostratigraphic correlation places emphasis on:

(1) Should the Australian stratigraphic scheme be adopted on a global basis where graptolite faunas allow correlation or is it preferable to erect a local biostratigraphic zonation even when the faunal succession is similar to that of Australia?

(2) Which chronostratigraphic scheme (North American, Australian or British) is most suitable for use in deep-water sedimentary deposits?

(3) Do Lower-Middle Ordovician graptolites show true provincialism, as opposed to the almost cosmopolitan distribution of Upper Ordovician taxa?

AUSTRALIAN STRATIGRAPHY

Some recent Canadian publications (e.g., James and Stevens, 1986; Lenz, this volume) have utilized the Australian graptolite-based chronostratigraphy in order to subdivide and correlate local, well-developed successions. Such incorrect adoption of chronostratigraphy for biostratigraphical correlation renders necessary clarification of the basis for the Australian stratigraphical scheme as defined by Webby and others (1981). In chronostratigraphical terms, the Ordovician of Australia is divided into three series, namely, the Lower, Middle and Upper Ordovician. The Lower Ordovician Series (Figure 1) is composed of the Lancefieldian, Bendigonian, Chewtonian, Castlemainian and Yapeenian Stages; the Middle Ordovician Series is equivalent to the Darriwillian Stage while the Upper Ordovician Series contains the Gisbornian, Eastonian and Bolindian Stages. Each stage is divided into several chronozones, based directly on equivalent graptolite biozones.

Thus, while each chronozone represents a time interval present on a global scale, regardless of whether diagnostic graptolites are present (Hedberg, 1976, p. 69), the equivalent biozones may only be recognized where similar faunal assemblages occur. Where such assemblages are present outside the Australasian continent, they are unlikely to cover exactly equivalent time spans and, although similar, are rarely identical in terms of taxonomic composition and species ranges. Because of this deficiency, and indeed due to definition, correlation with graptolitic successions elsewhere is biostratigraphic, rather than chronostatigraphic. Australian graptolite biozones, not chronozones, should therefore be employed when attempting global correlation. Usage of shorthand terms such as "Cal" for the *I. v. lunatus* Zone of the Australian Castlemainian Stage is therefore misleading.

In their study of the Cow Head Group, western Newfoundland, James and Stevens (1986) made accurate biostratigraphical subdivisions based on Australian stratigraphy, but referred to these divisions in terms of chronozones. Lenz (this volume) purports to make stage-by-stage chronostratigraphical correlation between the Australian succession and a region in the Yukon, northern Canada. The end result is essentially, however, a rather coarse biostratigraphy forced on a continuous, richly graptolitic succession. The Australian stratigraphy is not particularly appropriate for either area of

SYSTEM	COW HEAD GRAPTOLITE BIOSTRATIGRAPHY	COW HEAD CONODONT BIOSTRATIGRAPHY	BRITISH CHRONOSTRATIGRAPHY			BRITISH GRAPTOLITE BIOSTRATIGRAPHY	U.S. CHRONO-STRAT.	U.S. GRAPTOLITE BIOSTRATIGRAPHY	AUSTRALIAN CHRONOSTRATIGRAPHY			AUSTRALIAN GRAPTOLITE BIOSTRATIGRAPHY
			PRESENT SERIES	PROPOSED SERIES	STAGE				SERIES	STAGE	ZONE	
ORDOVICIAN	fauna not known – – – ? – – –	no zones yet designated	LLAN-VIRN – ? –	LLANVIRN	(or Arenig d)	G. dentatus (ex D. bifidus)	WHITEROCKIAN	P. etheridgei	MIDDLE ORDOVICIAN	Darriwilian	Da2	G. intersitus
	U. austrodentatus		ARENIG			D. hirundo		Isograptus			Da1	G. austrodentatus
	I. v. maximus			ARENIG	c				LOWER ORDOVICIAN	Yapeenian	Ya3	A. crudus
											Ya2	C. morsus
											Ya1	O. upsilon
										Castlemainian	Ca3	I. v. maximus
	I. v. victoriae										Ca2	I. v. victoriae
	I. v. lunatus	P. evae				I. gibberulus	– ? – IBEXIAN	D. bifidus			Ca1	I. v. lunatus
	D. bifidus				b	D. nitidus				Chewtonian	Ch2	D. protobifidus
								D. protobifidus			Ch1	D. protobifidus & T. fruticosus
	P. fruticosus					D. deflexus		T. fruticosus (3 & 4 branch)		Bendigonian	Be4	T. fruticosus (3 branch)
						graptolites not present		T. fruticosus (4 branch)			Be3	T. fruticosus (3 & 4 branch)
	T. akzharensis	P. elegans			a			T. approximatus			Be2	T. fruticosus (4 branch)
	T. approximatus										Be1	T. fruticosus & T. approximatus
										Lancefieldian	La3	T. approximatus
	'neodichograptid' dendroid fauna	no zones yet designated	– ? – TREMADOC	TREMADOC	x	no zones designated		Adelograptus & Clonograptus			La2	A. victoriae
	no zones yet designated					C. tenellus		Anisograptus			La1.5	Psigraptus & Clonograptus
						D. flabelliforme					La1	D. scitulum & Anisograptus
CAMBRIAN												

Canada; although the successions of faunal ranges show a clear overall similarity, the assemblages are rarely identical to those in Australia and a degree of potential biostratigraphical precision is therefore lost.

The writer considers that all relatively complete fossiliferous successions in geographically isolated areas should be subdivided using a locally-developed biostratigraphy appropriate to the succession of faunal assemblages present in that particular region. This local biostratigraphic scheme may be correlated subsequently with successions elsewhere and integrated into chronostratigraphic divisions. Such a procedure has been achieved with success through taxonomic and biostratigraphic study of Lower-Middle Ordovician graptolites from the Cow Head Group, western Newfoundland (Williams and Stevens, *Submitted*). Here it was recognized that although the faunal succession was broadly similar to that of Australia, the biostratigraphy (or chronostratigraphy) of that country was not suitable for direct adoption. The newly erected biostratigraphy, however, permits precise correlation both within the Cow Head Group and with graptolitic successions elsewhere in the world.

APPLICABILITY OF CHRONOSTRATIGRAPHIC SCHEMES

Ongoing research concerning Lower-Middle Ordovician deep-water successions of eastern Canada has demonstrated the difficulty in employing standard North American chronostratigraphy. Arguments for and against use of the Australian chronostratigraphy have been discussed above. Although this is potentially usable, many important faunal changes occur within stages and several stage boundaries are not adequately recognizable in eastern Canada.

The North American chronostratigraphy is naturally accepted as the primary chronostratigraphic scheme throughout the Ordovician of this continent. Following much confusion in definition and discrepancies in terminology, Ross and others (1982) suggested for series for the Ordovician, namely, the Ibexian, Whiterockian, Mohawkian and Cincinnatian. Of these, the only one to be subdivided is the Upper Ordovician Cincinnatian Series which includes the Edenian, Maysvillian and Richmondian Stages. All chronostratigraphic divisions of the North American Scheme are based on shallow marine trilobite, brachiopod and conodont data; correlation with deep-water graptolite and conodont successions is consequently uncertain (Figure 1), despite recent studies of localities in western Newfoundland yielding mixed assemblages (e.g., Ross and James, 1986; Williams and others, *Submitted*).

British chronostratigraphic division of the Early Ordovician (Cowie and others, 1972; Williams and others, 1972) is somewhat vague at the original localities in Wales where complete fossiliferous sequences spanning the Tremadocian, Arenigian and Llanvirnian Series are lacking. Each of the three series is, however, characterized by clearly recognizable shelly, conodont and graptolite faunas with major changes in all faunal groups at or near the boundaries. These series therefore meet the major requirements of a chronostratigraphic division in having marked faunal distinctions shown by several unrelated fossil groups and in being correlatable with equivalent intervals elsewhere in the world. Precise definition of the series boundaries and subdivision into stages is, however, lacking.

Wales clearly is an unsuitable area in which to define the series boundaries (e.g., Zalasiewicz, 1984), but this could be achieved in another region with continuous, mixed faunal control and sedimentation. The Cow Head Group of western Newfoundland meets these criteria; although breaks are present in both fauna and sedimentation, these are relatively unimportant and well understood. A rich faunal assemblage including graptolites, conodonts, trilobites, brachiopods, other shelly macrofossils, chitinozoa, radiolaria and palynomorphs occurs throughout strata spanning the Tremadocian to late Arenigian. Although the series names might then be considered somewhat inappropriate, retention could be argued in favour of nomenclatorial stability.

Chronostratigraphic division of the Tremadocian into stages has, in general, not been considered by the present author. One exception is the uppermost portion of the series which yields a distinctive, rich, "neodichograptid" dendroid fauna throughout the world and clearly merits stage division. The *Tetragraptus approximatus* Zone is not represented in Wales or northern England. However, if this zone is taken to mark the basal Arenigian, the series might be divided into three, or possibly four stages. These would be defined primarily in terms of graptolite assemblages, although conodonts also appear to show marked changes at similar levels. These stages would be readily usable in deep-water and some shallower water, black shale successions throughout North America, Australasia, Scandinavia and Britain.

The following summary of graptolite biostratigraphy in the Cow Head Group (Figure 1), including limited taxonomic revision, is taken from Williams and Stevens

Figure 1 **Correlation chart showing representative chronostratigraphic and biostratigraphic schemes considered in this article. Information from Williams and others (1972), Webby and others (1981), Ross and others (1982), Williams and Stevens (*Submitted*) and C.R. Barnes, D.I. Johnson and S.M. Pohler (pers. comms.).**

(*Submitted*). The first Arenigian stage would cover the *Tetragraptus approximatus* and *Tetragraptus akzharensis* zones, where an early dichograptid fauna of fairly low diversity is accompanied by a rich planktonic dendroid assemblage including *Rhabdinopora* and *Clonograptus*. The second stage would embrace the *Pendeograptus fruticosus* and *Didymograptus bifidus* zones. The latter zones have a rich dichograptid fauna, including *Pendeograptus fruticosus*, *Dichograptus*, *Tetragraptus* and extensiform and pendent *Didymograptus*, accompanied by abundant sigmagraptids and *Phyllograptus*. The earliest *Isograptus*, *I. primulus* (=*I. gibberulus*, *pars*?) occurs at the top of this interval. The third stage would cover the *Isograptus victoriae lunatus*, *I. v. victoriae* and *I. v. maximus* zones. It would be characterized by subspecies of the *Isograptus victoriae* lineage, together with *Pseudotrigonograptus*, *Pseudisograptus* and other *Isograptus* taxa. Neither pendent nor extensiform *Didymograptus* appear to be present during this interval in western Newfoundland although they may occur elsewhere. *Xiphograptus* diversifies and occupies the niche left vacant by these taxa. *Tetragraptus* and *Dichograptus* remain locally abundant, as do the sigmagraptids.

The base of the *Undulograptus austrodentatus* Zone is marked by the appearance of earliest unequivocal diplograptids, together with *Paraglossograptus* and *Cryptograptus*. These genera have a metasicular origin for th11, in contrast to the almost ubiquitous prosicular origin of earlier graptoloids. Several species of *Isograptus*, *Pseudisograptus*, *Tetragraptus* and *Xiphograptus* continue from the previous zone while a number of new sinograptid genera appear. This horizon correlates with the Lower-Middle Ordovician series boundary of Australia and is readily recognizable throughout most of the world. It currently is placed within the Arenigian Series, but would provide an excellent level at which to place an Arenigian-Llanvirnian boundary to be defined in the future on the basis of graptolites. Alternatively, this interval could be designated a fourth stage of the Arenigian Series.

GRAPTOLITE PROVINCIALISM DURING THE ORDOVICIAN

Major differences in terms of Lower and Middle Ordovician graptolite faunal assemblages were noted by Skevington (1969, 1974) between localities in Australia and North America and those of Britain (excluding Scotland) and Scandinavia. He proposed a division into Pacific and Atlantic faunal provinces (see also Jackson, 1978) that were considered to represent warm and equatorial versus cool and higher latitudes, respectively. Subsequent research has demonstrated "mixed" faunas of this age in western Newfoundland (Finney and Skevington, 1979; Williams and Stevens, *Submitted*), central Norway (Schmidt, 1984) and southern Sweden (pers. obs.).

Explanation of this apparent division into two dissimilar assemblages appears to be twofold. First, it is an artifact of bibliographic usage in which earlier Scandinavian and British workers placed emphasis on publications from those regions while researchers in North America and Australia concentrated on literature from their own continents. Even a cursory examination of illustrated material reveals a host of hitherto unrecorded synonymies.

The second explanation is real but, rather than a result of true provincialism, is here thought to be due to preservation of a typical open ocean fauna with what was probably a partially restricted, shallow-water assemblage. Although similar black shale depositional environments no longer exist, recent observations suggest that anoxic, starved sedimentation may have occurred in widespread, relatively shallow shelf settings during Early Paleozoic times. Such an environment would explain more easily the rhythmic alternation of black, graptolitic shales and pale limestones yielding a typical marine shelf assemblage, such as are found throughout the Lower Ordovician of southern Scandinavia. Such lithological variation has been considered by some authors to be a product of wildly fluctuating sea levels, but it may represent nothing more than subtle changes in water circulation and the calcium compensation depth.

Support for this hypothesis is lent by the mixed "Pacific" and "Atlantic" Lower Ordovician graptolite assemblages of northeast Scania, southern Sweden (pers. obs. of borehole material, Lund University) and of Bogo, central Norway (Schmidt, 1984). It is also confirmed to a lesser extent by assemblages from Gausdal, southern Norway (Williams, 1984) and from the Cow Head Group, western Newfoundland (Williams and Stevens, *Submitted*). Further work is needed on the fauna and sedimentology of the Skiddaw Group, northern England and Llanvirnian strata of South Wales before their environmental setting may be deduced. Critical work in both these areas and elsewhere may confirm or disprove this hypothesis.

REFERENCES CITED

Cowie, J.W., Rushton, A.W.A., and Stubblefield, C.J. 1972. A correlation of Cambrian rocks in the British Isles. Geol. Soc. London Spec. Rept. 2, 42 p.

Finney, S.C. and Skevington, D. 1979. A mixed Atlantic-Pacific province Middle Ordovician graptolite fauna in western Newfoundland. Can. J. Earth Sci. 16:1899-1902.

Hedberg, H.D. (ed.). 1976. International Stratigraphic Guide. Wiley and Sons, 200 p.

Jackson, D.E. 1978. Recent developments in graptolite research. *In* Stelck, C.R. and Chatterton, B.D.E. (eds.), Western and Arctic Canadian biostratigraphy. Geol. Assoc. Can. Spec. Paper 18:113-131.

James, N.P. and Stevens, R.K. 1987. Stratigraphy and correlation of the Cambro-Ordovician Cow Head Group, western Newfoundland. Geol. Surv. Can. Bull. 366.

Lenz, A.C. (this volume). Ordovician series/stages, graptolitic basinal facies, northern Yukon, Canada.

Ross, R.J., Jr. and others. 1982. The Ordovician System in the United States, correlation chart and explanatory notes. Int. Union Geol. Sci. Pub 12, 73 p.

____________ and James, N.P. 1986. Biostratigraphy of the Cow Head and Table Head Groups, western Newfoundland, as indicated by Middle Ordovician brachiopods. Can. J. Earth Sci.

Schmidt, O. 1984. The graptolitic facies of the Bogo Shale (Arenig-Llanvirn), at Trondelag, west central Norway. Geol. et Paleont. 18:17-19.

Skevington, D. 1969. Graptolitic faunal provinces in Ordovician of northwest Europe. Amer. Assoc. Petrol. Geol. Mem. 12:557-562.

____________ 1974. Controls influencing the composition and distribution of Ordovician graptolite faunal provinces. *In* Rickards, R.B., Jackson, D.E., and Hughes, C.P. (eds.), Graptolite studies in honour of O.M.B. Bulman. Spec. Papers in Palaeont. 13:59-73.

Webby, B.D. and others. 1981. The Ordovician System in Australia, New Zealand and Antarctica. Int. Union Geol. Sci. Pub. 6, 64 p.

Williams, A. and others. 1972. A correlation of Ordovician rocks in the British Isles. Geol. Soc. London Spec. Paper 3, 74 p.

Williams, S.H. 1984. Lower Ordovician graptolites from Gausdal, central southern Norway: a reassessment of the fauna. Norges Geol. Unders. Bull. 395:1-24.

____________, Boyce, W.D., and James, N.P. (*Submitted*). Ordovician (Arenig-Llanvirn) graptolites from the St. George and Table Head Groups, western Newfoundland and implications for correlation of trilobite, brachiopod and conodont zones. Can. J. Earth Sci.

____________ and Stevens, R.K. (*Submitted*). Early Ordovician (Arenig) graptolites from the Cow Head Group, western Newfoundland. Palaeontogr. Can.

Zalasiewicz, J.A. 1984. A re-examination of the type Arenig Series. Geol. J. 19:105-124.

1986 Canadian Paleontology and Biostratigraphy Seminar and Sesquicentennial Celebration of the New York State Geological Survey

The geological diversity of the Albany region has long served as a catalyst for geological syntheses that are applicable well beyond the boundaries of New York State. Several geological provinces lie within an hour's drive of the City. The ancient rocks of the Canadian Shield compose the Adirondack Mountain dome to the north. Shallow marine sequences of Cambrian and Ordovician age overlie this basement and dominate the St. Lawrence-Lake Champlain-Mohawk River Valley lowlands and Tug Hill Plateau. Remnants of the ancestral North American continental margin were thrust westward out of present day New England by the collision of northeastern North America with a volcanic island arc during the Middle Ordovician Taconic orogeny. Allochthonous (transported) rocks from this mountain building episode lie along the eastern side of the Hudson River. Younger Silurian and Devonian marine sequences overlook Albany from the Helderberg and Black Head Mountains to the southwest while the eroded debris of the Acadian orogen forms the high peaks of the Catskill Mountains on the southern horizon. This second mountain building episode resulted from the collision and welding of eastern North America with a continent-sized mass called Avalon in the Devonian.

The Lower and Middle Paleozoic sequences of the Albany area are very fossiliferous. As a result, the rocks of the region have come to represent a standard for world-wide relative time correlation and for the reconstruction of ancient environments.

It is hoped that these field guides will convey and synthesize information for the participants at the Seminar. In addition, the guides are designed to serve as useful aids for educators in designing their own field trips on the geological evolution of New York State. The rocks and fossils of New York are a vulnerable resource in a populous state. Many classic localities, such as the Deep Kill section, have been badly damaged by collectors over recent years and their utility as teaching and research aids has suffered. We encourage instruction and self education through observation; we strongly discourage casual or commercial collecting or any other vandalism of New York State's geological heritage.

Depositional Tectonics and Biostratigraphy of the Western Portion of the Taconic Allochthon, Eastern New York State

Ed Landing
New York State Geological Survey, The State Education Department

SUMMARY

A record of the Early Paleozoic tectonic history of the northeastern margin of North America is spectacularly preserved in the western portion (Giddings Brook slice) of the Taconic allochthon, eastern New York State. The allochthonous sequence was pushed onto the foundered autochthonous platform during the Middle Ordovician Taconian orogeny. In the Taconic allochthon, latest Precambrian or Early Cambrian rift margin facies are succeeded by Early Cambrian through early Middle Ordovician passive margin, deep water (lower slope to ?rise) muddy sediments with biostratigraphically important faunas. The stratigraphy of the latter interval is based, to a large extent, on overall rock color (green-reddish vs. black) that reflects oxic vs. strongly dysaerobic/anoxic bottom water conditions. The sequence provides strong evidence against the claims that the world ocean was not oxygenated to depth until the Late Paleozoic. Dark sediment-dominated intervals in the passive margin sequence probably reflect times of major eustatic sea level rise. The passage of the forearc peripheral bulge through deep water depositional sites probably is indicated by condensed, reddish passive margin sediments in the Taconic allochthon (Indian River Formation) and several other orogenic belts. Easterly-derived flysch appears in the allochthonous Taconic sequence during convergence of the North American continent with the emergent, offshore accretionary prism and volcanic arc.

INTRODUCTION

The Taconic allochthon extends as a continuous range of low hills and mountains for approximately 200 km from the vicinity of Sudbury, Vermont, to Beacon, near Poughkeepsie, New York (Figure 1). The allochthon is a prominent physiographic unit dominated by Cambrian-Ordovician siliciclastics that lie along the trend of largely coeval platform carbonates and sandstones of

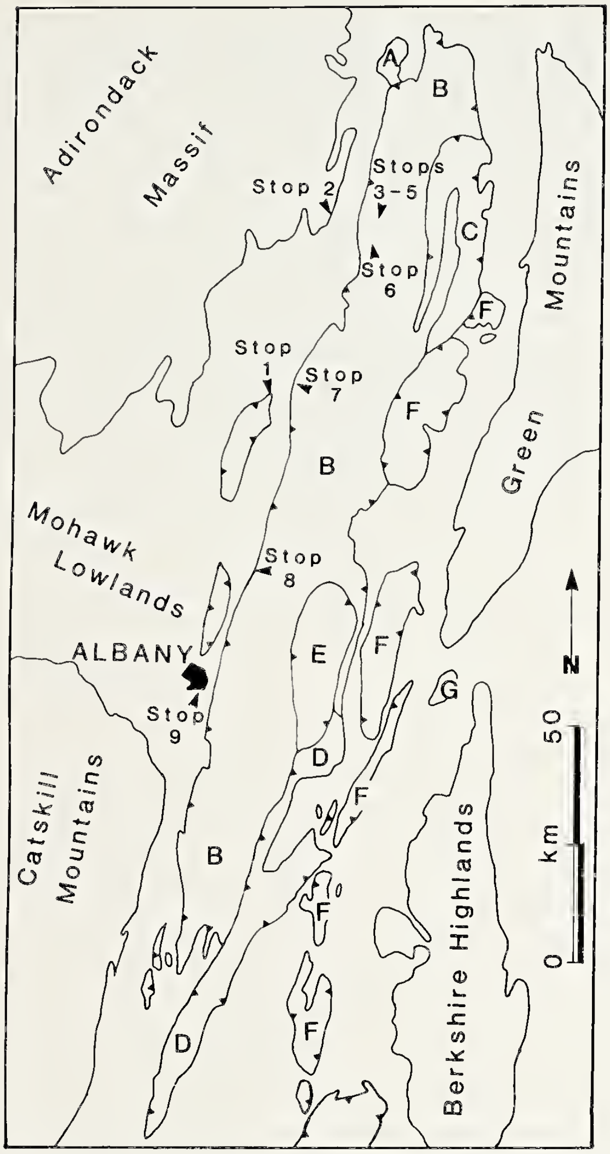


Figure 1 **Generalized locality map for field trip. Major thrustbounded slices of the Taconic allochthon indicated by letters: A, Sunset Lake slice; B, Giddings Brook slice; C, Bird Mountain slice; D, Chatham slice; E, Rensselaer Plateau slice; F, Dorset Mountain-Everett slice; G, Greylock slice. Map modified from Zen (1967).**

the Middlebury synclinorium to the north in Vermont. The Taconic allochthon lies east of the Hudson River-Lake Champlain Lowland (=west limb of the Middlebury synclinorium, locally) and west of the Vermont Valley (=east limb of Middlebury synclinorium).

Structural features generally parallel the north-northeasterly trend of the allochthon while regional metamorphic grade increases to the east across the breadth of the allochthon (ca. 20-30 km). Regional metamorphism ranges from low chlorite grade in the slaty sequences at the leading (western margin) to biotite grade in the highest peaks along the border between New York and Massachusetts and Connecticut. The higher grade metamorphism in the eastern Taconics is post-Ordovician and radiometric dates are Middle and Late Devonian (e.g., Zen and Hartshorn, 1966). Color alteration indices (CAI) of conodont elements (Epstein, Epstein and Harris, 1977) from the western portion of the Taconic allochthon and autochthonous, structurally underlying carbonates average 4.5, suggesting burial depths of approximately six kilometers and temperatures near the upper thermal limit for dry gas production (author's data). By comparison, CAI's at the leading edges of the Taconian allochthons in the Cow Head region, eastern Newfoundland (Landing, *In* Fortey and others, 1982), and along the south shore of the St. Lawrence River, Quebec (Landing, Barnes and Stevens, 1986), are significantly lower (1.5 and 2.5, respectively) and fall within the hydrocarbon window. Recent exploration drilling in the Easton, New York, area has hopefully yielded new information on Taconic structure and stratigraphy but seems unlikely to lead to any production.

The lateral stratigraphic continuity of the Taconic sequence has been disrupted by thrusting that has produced seven major imbricated slices (Zen, 1967). These include the structurally lowest Sunset Lake slice and the structurally highest Greylock slice (Figure 1). An obvious consequence of this telescoped imbricate structure is that higher, more easterly and metamorphosed slices tend to preserve a record of somewhat older and more offshore rocks than the underlying slices. As a result, fossiliferous Cambrian and Ordovician rocks are limited to the younger, less deformed and least metamorphosed sequences in the western portion of the Taconic allochthon.

A key aid in defining the major slices of the Taconic allochthon are exotic, frequently massive carbonate blocks (Zen, 1967; Potter, 1972) and slices of Grenvillian crystalline basement (Ratcliffe and Bahrami, 1976) that crop out along the leading and trailing edges of the slices. The carbonate blocks are frequently fossiliferous; Lower Ordovician through Middle Ordovician (Black River and Trenton) faunas have been recovered from them and indicate a maximum age for transport and internal thrusting of the allochthon. The lithologies of the boulders correspond to those present in the westerly dipping Vermont Valley sequence and Middlebury synclinorium and provide evidence that westerly transport of the Taconic allochthon occasionally resulted in a shearing-off of autochthonous units at the sole of the allochthon. As the allochthon itself underwent shear and internal thrusting, these carbonate boulders were entrained along the thrust surfaces between the internal slices.

The master-thrust of the Taconic allochthon is everywhere underlain by an autochthonous to parautochthonous wildflysch (Stops 1 and 7) that contains blocks (pebble- to kilometer scale) of Taconic sequence lithology, scattered carbonate boulders identical to those lying along the internal thrusts, and redeposited wildflysch. This characteristic "blocks in shale" (Berry, 1962) has been reported under various names (Forbes Hill Conglomerate, Whipstock Breccia, Poughkeepsie melange; see Zen, 1964; Fisher, 1977) and is significant because graptolites (Berry's (1960, 1962) *Orthograptus truncatus* var. *intermedius* Zone) occur in the dark shale and sand matrix. The graptolites indicate the arrival of the Taconic allochthon by the middle Caradocian in eastern New York State.

TECTONIC MODEL AND SYNOROGENIC SEDIMENTS

A number of recent publications (Chapple, 1973, 1979; Rowley and Delano, 1979; Rowley and Kidd, 1981; Rowley, Kidd and Delano, 1979; Stanley and Ratcliffe, 1985) have served to revise the earlier continent-arc collision-accretion model of the Middle Ordovician Taconian orogeny. Earlier models proposed development of an Andean-type volcanic arc on the margin of the Laurentian (North American) plate with subduction of oceanic lithosphere under Laurentia (Bird and Dewey, 1970). Subsequent uplift of this continent margin and associated collapse of the platform margin were the presumed causes of soft-sediment gravity sliding of backarc basin sediments (=low Taconics) onto the site of the submerged carbonate platform in the Middle Ordovician prior to subsequent hard-rock thrusting of the high Taconics in the late Middle and Late Ordovician (Zen, 1961, 1967).

The later models have changed the polarity of subduction (Chapple, 1973, 1979; Rowley and Delano, 1979; Rowley, Kidd and Delano, 1979) and essentially envision that (present) eastern North America converged on an off-shore volcanic island arc through subduction of the leading edge of the Laurentian plate underneath an oceanic plate. Deep-sea sediments of Cambrian-Ordovician age that have a North American provenance were "scraped off" in the subduction zone. Successive slices of sediment accumulated by underthrusting into an accretionary prism (Seely, Vail and Walton, 1974) occupying the trench inner slope and located in front of the leading edge of the overriding plate bearing the volcanic arc. This accretionary prism represents the first stage of development of the allochthonous Taconic sequence. The stacking-sequence of this model progresses from east to west with the structurally lowest slices being incorporated last and containing the youngest hemipelagic and North American-provenance sediments.

The first local evidence of the proximity of the island arc to North America is provided by volcanic ashes (Rowley, Kidd and Delano, 1979; Rowley and Kidd, 1981) in the red shale-dominated Indian River Formation (post-middle Llanvirnian to early Llandeilian [Berry, 1962; E.L., unpub. data]). These volcanic ashes are the earliest sediments that are demonstrably not of North American provenance in the Cambrian-Ordovician sequence of the Taconic allochthon. With further convergence and continued underthrusting, the accretionary prism was apparently elevated above sea level (e.g., Seely, Vail and Walton, 1974) and became an important source for turbidity-deposited sandstones (Austin Glen Formation, Caradocian) that accumulated in the trench and in deep water sites on the Laurentian plate in front of the trench. The occurrence of dynamically metamorphosed (foliated) and chromite grains provides evidence that the accretionary prism was emergent and contained slices of obducted sea floor (Rowley and Kidd, 1981). This unit itself is incorporated as the youngest stratigraphic unit in the accretionary prism. A number of northern Taconic workers prefer the name "Pawlett Formation" for this allochthonous flysch.

The later stage of the Taconian orogeny along the central to northern Appalachians featured a general foundering of the carbonate platform and a spread of black shale (locally calcareous) that preceded deposition of a parautochthonous or autochthonous flysch blanket, the Snake Hill Formation (Stevens, 1970; Rickard and Fisher, 1973). This subsidence is associated with emplacement of the Taconian allochthons on the margin of Laurentia and probably reflects both a downwarping of the continent as it entered the subduction zone (Rowley and Kidd, 1981; Shanmugam and Walker, 1980) and loading of the continent margin by the leading edge (accretionary prism and volcanic arc) of the offshore oceanic plate (Hiscott, Quinlan and Stevens, 1983; Quinlan and Beaumont, 1984).

The paleogeography of eastern New York near the end of convergence probably resembled that of northern Australia (=Laurentia analogue) and offshore New Guinea (=Taconian allochthon-volcanic island arc) where a relatively narrow sea currently separates an emergent clastic source that is overriding a continent with fringing carbonate platform. A facies transect across this Middle Ordovician seaway in eastern New York during the middle Caradocian (*Corynoides americanum* and *Orthograptus ruedemanni* Zones) featured dramatic lateral facies changes over a relatively short distance. Chaotic "blocks in shale" deposits at the toe of the advancing Taconian allochthon are the lateral equivalent of synorogenic flysch (Snake Hill Formation) in the lower Mohawk Valley, the lower Utica Shale in the central Mohawk Valley, and lower portion of the persistent platform margin deposits of the Trenton Group (see Mehrtens, 1984) in the upper Mohawk Valley (see Fisher, 1977). Cisne and Rabe (1978; Cisne and others, 1982) have provided a key synthesis for depositional environments in the western portion of this ca. 100 km wide seaway by applying a continent-arc collision model to explain biofacies and major lithofacies changes in terms of an easterly-dipping trench model with extensional tectonics and block faulting in the outer trench wall. Depth related benthic paleocommunities (Cisne and Rabe, 1978) are present in the westerly portion of the Trenton-Utica depositional belt but the progressive easterly depth increase suggested by these authors (Cisne and others, 1982) is questionable because many elements of the shallower water Trenton fauna reappear in the easterly Snake Hill facies belt (see Ruedemann, 1912, pp. 58-67).

STRATIGRAPHIC SEQUENCE

Nomenclature

A problem for Taconic stratigraphic and structural studies is the continuing generation of new stratigraphic names based on the relatively mediocre outcrops available in many local study areas. Although this practice is a natural consequence of problems of correlation between the major thrust slices, it is unfortunate that separate lithostratigraphic schemes exist for the northern, central and southern portions of the Giddings Brook slice (see Zen, 1964). In general, this guide follows Rowley, Kidd and Delano's (1979) lithostratigraphic scheme but with two exceptions.

The name "Deep Kill Formation" (Ruedemann, 1902) is used as the legitimate senior synonym for the "Schaghticoke Shale" (Ruedemann, 1903), "Poultney Slate" (Keith, 1932), and "Stuyvesant Falls Formation" (Fisher, 1961, 1962). Although Fisher (1961) argued that Ruedemann (1902) originally defined the "Deep Kill Shale" as a biostratigraphic unit from what is now known to be two slices at the sole of the Taconic master thrust, Ruedemann (1919) subsequently described the "Deep Kill Shale" as a greenish-grey shale-dominated lithologic unit of Early Ordovician age in the Taconics and used it as a map unit in the central and southern Taconics (Ruedemann and Cook, 1930; Ruedemann, Cook, and Newland, 1942). The type section of the Deep Kill Formation on the Deep Kill ("Kill" is Dutch for "Creek") includes representative lithologies (greenish-grey mudstones, quartz arenites and shales and black shale-limestone intervals) that characterize the coeval "Poultney" and "Stuyvesant Falls" in their type areas. Although not present at the type section of the Deep Kill Formation, the base of the Deep Kill is conveniently placed at the black-green boundary at the top of the Hatch Hill Formation. A local black shale-limestone interval that various authors have tried to assign to the lower Poultney (=Poultney A of Theokritoff, 1964; White Creek Member of Potter, 1972; Dunbar Member of Jacobi, 1977) is not lithically differentiable from and should be mapped as part of the upper Hatch Hill Formation. The contact between the Hatch Hill Formation and overlying Deep Kill Formation on Ganson Hill, southern Vermont (Aparisi, 1984) is marked by a meter-thick dolostone clast debris apron with conodonts of the *Rossodus manitouensis* Zone (Landing, Benus and Whitney, *Submitted*) of middle Tremadocian age (Landing, Barnes and Stevens, 1986).

A second problem is posed by the names applied to the Middle Ordovician synorogenic flysch because interpreted tectonic setting influences nomenclature. The "Pawlet Formation" is used at times to refer to flysch in stratigraphic continuity with the allochthonous Taconic sequence while "Austin Glen Formation" may or may not be preferred for coeval parautochthonous or autochthonous flysch at the leading margin of the allochthon (Potter 1972; Fisher, 1977; compare Rowley and Kidd, 1981; Fisher 1984). This latter tectonic setting may be the same as that of the lithically comparable type section of the Snake Hill Formation on Saratoga Lake.

Stratigraphic Thickness of Taconic Sequence

The Cambrian-Ordovician sequence of the northwestern portion of the Giddings Brook slice (Figure 2) is approximately 600 m thick. Rowley, Kidd and Delano (1979) followed Wood (1973, 1974) in estimating a 75% shortening of the section perpendicular to slaty cleavage on the basis of deformation in reduction spots in slates. They proposed a pre-deformational thickness of 2 km. However, severe tectonic thinning of this magnitude is questionable in the western portion of the Giddings Brook slice. The primary sedimentary structures and intraclasts from bedded limestones interbedded with shales, microfossils (phosphatic and organic walled) and larger fossil remains (trilobites, brachiopods, and echinoderm hash) from limestones, as well as primary sedimentary structures, trace fossils, graptolites and linguloid brachiopods in shales, and siliciclastic mudstone clasts in shale matrix debris aprons, in the author's experience, simply do not show the degree of tectonic thinning and deformation proposed by Wood. These primary lithologic features retain their characteristic proportions and convexity in the Giddings Brook slice.

Whether the actual post-compactional and pre-tectonic thickness of the Lower Cambrian through Caradocian is 600 or 2000 m, the Taconic sequence is significantly condensed by comparison with many coeval carbonate platform sequences. A spectacular example of sedimentary condensation, resulting from proba-

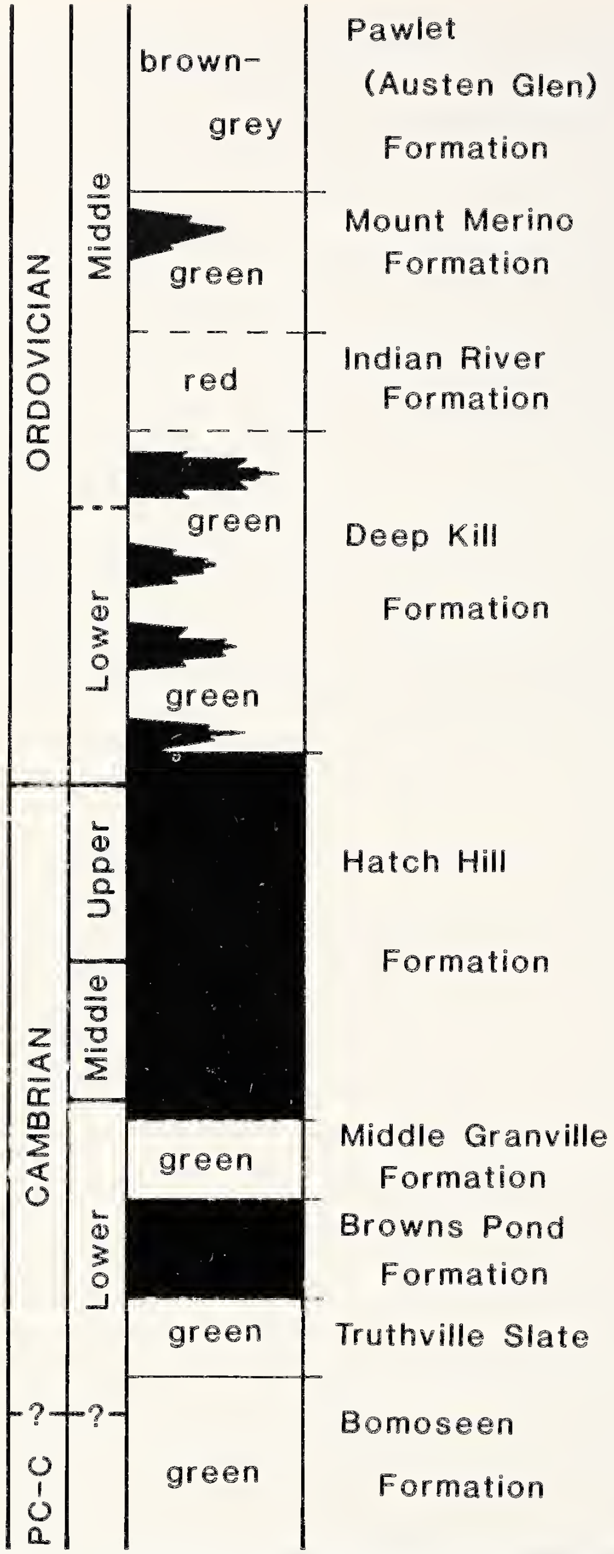


Figure 2 Generalized stratigraphy of the western portion of the Giddings Brook slice, western portion of the Taconic allochthon. Major color of siliciclastic mudstones indicated in column; black fields within column are black shale (with quartz arenites and limestones) dominated.

ble sediment by-passing and erosion associated with debris apron emplacement, occurs at Judson Point, near Hudson, New York, where only 25 m of section separates an Early Cambrian *Elliptocephala asaphoides* fauna from an upper Middle Cambrian *Bolaspidella* Zone-equivalent fauna (Bird and Rasetti, 1968).

Cambrian-Lower Middle Ordovician Units

The Rensselaer "Greywacke" represents one of the oldest units in the Taconic allochthon. This sequence of dark-grey to reddish, meter-scale, turbiditic, feldspathic litharenites with local pillow basalts (Bird, 1963; Potter, 1972) is a good candidate for a continent rift-margin marine facies. It is largely restricted to the Rensselaer Plateau slice where it is locally interbedded with Bomoseen-type feldspathic arenites and slates (Potter, 1972).

The transition from the frequently massive, poorly sorted, micaceous, feldspathic quartz arenites of the Bomoseen into the overlying (?and laterally equivalent) olive-green Truthville Slate (Rowley, Kidd and Delano, 1979; Aparisi, 1984) is relatively abrupt and represents the termination of significant feldspar input into the deep water Taconic sequence. Fossils are presently unknown from these units but the occurrence of the radiating *Chondrites*-like burrow *Oldhamia* from presumably laterally equivalent red and purple slates of the "Nassau Formation" to the south (Ruedemann, 1929) suggests an Early Cambrian age for this portion of the Taconic sequence.

The succeeding Lower Cambrian to lower Middle Ordovician (Browns Pond to Deep Kill formations) is an alternation of black shale-dominated and greenish to purplish shale-dominated units which are readily confused in the field. The first shelly fossils (trilobites, echinoderms, archaeocyathid fragments, molluscs, phosphatic problematica) of the lower *Elliptocephala asaphoides* fauna occur in slope-derived limestone blocks in debris flows (Stop 4) and, to a lesser extent, from bedded limestones in the upper part of the Browns Pond Formation. A number of Lochman's (1956) fossil localities came from the upper part of this unit. The green-black boundaries defining the base and top of the Browns Pond Formation are relatively sharp and several massively bedded, probably channelized, quartz arenites appear near the base of the formation (Stop 3).

The overlying Middle Granville Formation (Kidd, Rowley and Delano, in Fisher, 1984) was a major source of sea-green and purplish slate in the old slate industry in Washington County, New York. Nodular-bedded (probably largely diagenetic) limestones and thin limestone clast debris flows in the lower and middle portions of the unit produced Lochman's (1956) upper *Elliptocephala asaphoides* fauna. The transition from the Middle Granville Formation into the Hatch Hill Formation is the second green-black boundary in the Taconic sequence. The Hatch Hill Formation is frequently readily recognizable in the field by its characteristic orange-weathering, dolomitic quartz arenites (dm- to m-scale thickness) in dark-grey to black shales. The Hatch Hill was deposited over an extremely long interval of time and faunas range in age from the late Early Cambrian (*Acimetopus bilobata* trilobite fauna of Rasetti, 1967) through the earliest Ordovician *Dictyonema flabelliforme*-lower conodont Fauna B interval (Landing, 1988) and *Rossodus manitouensis* Zone (Landing, Barnes and Stevens, 1986) [=early and middle Tremadocian, respectively]).

The transition from the Hatch Hill Formation into the Deep Kill Formation is another black-green boundary in the Taconics. This formational contact is associated with a significant decrease in the input of shelf-derived quartz sand. The transition from black to greenish shale represents a probable return to somewhat more oxic bottom conditions. However, black shale-limestone intervals of middle Tremadocian and early, middle and late Arenigian age occur in western areas of the Deep Kill outcrop belt and represent long term anoxic slope water conditions. These black shale-limestone intervals temporally correlate with similar black shale intervals in the Taconian allochthons in Quebec and with strong cumulative onlaps on the North American platform (Landing, Benus and Whitney, *Submitted*). The latter authors have proposed that black shale-limestone intervals within green shale-dominated units like the Deep Kill and Levis Formations are the result of an intensification and thickening of a dysaerobic to anoxic water mass that characterized the upper slope in the Quebec Reentrant during the Early and early Middle Ordovician. This poorly oxygenated mid-water mass is believed to have "thickened" and moved down slope with increased shelf organic productivity, generation of dense, warm, higher salinity shelf waters with reduced oxygen solubility, and warmer climates with restricted deeper water circulation at times of major Early and early Middle Ordovician onlap (Landing, Benus and Whitney, *Submitted*). Two of these black shale-limestone intervals (the middle and upper Arenigian) will be seen at Stop 8.

The greenish shale intervals of the Deep Kill have received somewhat less study, in part because they are less productive of fossil material. Along-slope transport and reworking of quartz sand by north-northeasterly flowing contour currents has been reported from the greenish-shale dominated intervals of the Deep Kill Formation (Aparisi, 1984). The youngest conodont faunas from the Deep Kill Formation represent the *Eoplacognathus suecicus* Zone and have been recovered from a ca. 20 m thick interval of calcareous quartz arenites and green shales at a locality near Raceville, New York. Comparable facies and associated conodonts are present in the upper part of the Levis Formation at Levis, Quebec, in what Landing and Benus (1985) termed the middle and upper *Shumardia* "Limestone". These occurrences suggest a brief influx of shelf-derived quartz sand and coarse-grained carbonate during the middle Llanvirnian on the continental slope in eastern New York and the Levis, Quebec, region. Black shale-limestone intervals and the upper calcareous quartz arenites of the Deep Kill Formation have yielded abundant North Atlantic Province (e.g. unrestricted open marine) conodonts that allow interprovincial correlation of the classic graptolite faunas (see Ruedemann, 1902, 1903) of the Deep Kill Formation (e.g., Landing, 1976).

Indian River Formation – Deep-water Oxygenated Sediments

The three formations of the post-Deep Kill sequence, known as the Normanskill Group, are highly dissimilar Middle Ordovician units. The lower unit, the Indian River Formation (Keith, 1932) was important in the early slate industry of eastern New York State because of its strikingly colored, bright red to blue green and purple slates that contain few quartz arenites (known as "ringers" in the trade because of the sound they made when struck with a hammer). Fossils are poorly known from the Indian River. Ruedemann and Wilson (1936) described radiolarians from cherty horizons that appear locally in the formation while Berry (1962) cited Warthin's personal communication of the discovery of Llandeilian or early Caradocian *Nemagraptus gracilis* specimens from the formation.

The thin (ca. 50 m) Indian River Formation is a problematical unit in the Taconic sequence. Fisher (1961) attributed its red color to the deposition of lateritic sediments eroded from the platform during development of the "Knox unconformity." An alternative explanation is that the relatively homogeneous mudstones of the unit were completely bioturbated, very slowly deposited muds that had a long residence time on the oxygenated sea floor. The occurrence of recrystallized, radiolarian-rich cherty beds may reflect a lack of terrigenous dilution of the local pelagic sediment sources. Long sediment residence time at the oxygenated sea floor, rather than quick burial of hemipelagic mud (compare Hesse and Ogunyomi, 1982) is preferred as an explanation for the red color of the slates of the Indian River Formation while the thin greenish sands of the unit were probably shielded from oxygenated environments by their relatively rapid depositional rate.

Cherty grey to red slates similar to the Indian River Formation are widespread in approximately coeval (Llanvirnian-lower Caradocian) pelagic sequences of the Southern Uplands of Scotland (Leggett, 1978). Well-oxygenated conditions may have been widespread through the deeper water masses of the Iapetus Ocean in this portion of the Middle Ordovician. Indeed, if the Cambrian-Ordovician sequence of the Taconic allochthon reflects deeper oceanic circulation, the Early Cambrian had two intervals of relatively oxic conditions (pre- and post-Browns Pond), an interval of dysaerobic conditions punctuated by middle Tremadocian and early, middle, and late Arenigian anoxia represented by the Deep Kill Formation, and middle Llanvirnian (or later) to Llandeilian oxygenation (=Indian River Formation). Berry and Wilde's (1978) claim that the world ocean became ventilated to depth only by the Late Paleozoic is certainly not substantiated by the evidence from eastern New York State or Quebec (E. L., in prep.).

A further contributing factor to the red color of the Indian River Formation may have been passage of the peripheral bulge through the site of deposition of the Taconic sequence. The magnitude of upward flexure associated with passage of this stationary wave through an oceanic slab is as great as 500 m at a 120-150 km distance from the subduction zone (Jacobi, 1981). As deep-sea floor and the oceanic-continent transition zone (rise-lower slope region) passes across this zone of upward flexure during its progress toward a subduction zone, sedimentary condensation might be expected to result from ponding of sediments on the continental and accretionary prism sides of the bulge. With limited accumulation rates, pelagic sediments (radiolarites) and thin, well-oxygenated hemipelagic muds would characterize the region of the bulge. This site of condensed sedimentation would descend from the bulge with continued convergence and come under the influence of accretionary prism-arc related depositional systems as it approached the subduction zone. A relatively short to long hemipelagic sequence may appear above the condensed interval before the onset of flysch sedimentation in the vicinity of the outer trench wall. The duration of this interval of hemipelagic deposition would be dependent on the speed of convergence and the distance that flysch was transported away from the accretionary prism-arc sediment source. Slow rate of convergence and restriction of flysch to sites adjacent to the trench would be a situation, for example, where relatively long term hemipelagic sedimentation would succeed a condensed interval. This hemipelagic sequence (?=Mount Merino Formation) would then be succeeded by prism-arc derived turbidite sedimentation (Austin Glen Formation).

These stratigraphic relationships appear to be present in pre- and early orogenic settings in a number of regions. Red shales in the more distal portion of the Cow Head Group at St. Paul's Inlet, western Newfoundland (*Isograptus caduceus* var. *victoriae* Zone; see Kindle and Whittington, 1958) and the condensed Cephalopodenkalk in the Rheinisches Schiefergebirge and Harz Mountains, West Germany (Upper Devonian [Famennian], Tucker, 1973) are succeeded by synorogenic flysch. Interestingly, the Cephalopodenkalk has sheet cracks and neptunian dykes that suggest the episode of uplift and extensional tectonics that would be expected with passage of a peripheral bulge on the external margin of a subduction zone.

Because the zone of subduction along an accretionary prism/arc margin is unlikely to parallel that of a converging continent, the condensed sediment interval associated with passage of a peripheral bulge through a subducting oceanic plate or oceanic-continent transitional area will be a diachronous unit along an orogen. This is evident within the Taconian allochthons because red shales of this type are late Arenigian in western Newfoundland (cited above) and post-middle Llanvirnian in eastern New York State.

Upper Part of Normanskill Group

The Indian River Formation is abruptly transitional into the overlying Mount Merino Formation of Cushing and Ruedemann (1914). The internal stratigraphy of the Mount Merino and its depositional environments have received little study and only a few tentative suggestions can be made about the tectonic significance of the unit.

The Mount Merino is frequently a greenish-grey shale with mm- to cm-thick quartz arenites (Stop 5) that resembles parts of the Deep Kill Formation. Greenish chert horizons with radiolaria (Ruedemann and Wilson, 1936) occur in the lower portion of the unit while pyritiferous, graptolitic black shales, such as those present at the type locality on Mount Merino near Hudson, New York, may be more characteristic of the upper part of this relatively thin (ca. 50 m) formation (Rowley, Kidd and Delano, 1979). The origin of these dark sediments within the upper part of the Mount Merino (representing Berry's (1960, 1962) *Nemagraptus gracilis* to *Climacograptus bicornis* Zones) may be due largely to the oceanographic changes and widespread deep-water anoxia associated with early Caradocian eustatic onlap (Leggett, 1978). However, the upper part of the Mount Merino appears to be a relatively silty unit, and its dark color may also reflect increased rate of deposition of distal turbidite deposits that originated on the flanks of the emergent accretionary prism/arc.

The upper contact of the Mount Merino is marked by the appearance of cm- to m-thick quartzose litharenites in grey to black shales. The turbidite-dominated Austin Glen Formation (Ruedemann, Cook and Newland, 1942; or Pawlet Formation of Zen, 1961) probably accumulated in the middle Caradocian (Berry's (1960, 1962) *Climacograptus bicornis* and *Orthograptus truncatus* var.

intermedius Zones) on the outer and inner trench slopes and trench axis in the allochthonous Taconic sequence. This same facies spread as a parautochthonous to autochthonous blanket across the foundered platform with thrusting of the allochthon onto the partially subducted continental margin.

ACKNOWLEDGMENTS

Earlier portions of work on Taconic stratigraphy and biostratigraphy were supported by National Science Foundation Grant EAR76-10601 (F.H.T. Rhodes, Principal Investigator). W.S.F. Kidd and D.B. Rowley are thanked for many productive discussions. Numerous sections were studied with A.P. Benus.

REFERENCES CITED

Aparisi, M. 1984. Stratigraphy and structure of the Ganson Hill area, northern Taconic allochthon. Master's thesis, SUNY at Albany, 128 p.

Berry, W.B.N. 1960. Graptolite faunas of the Marathon region, west Texas. Univ. Texas Pub. 6005, 179 p.

__________ 1962. Stratigraphy, zonation, and age of Schaghticoke, Deepkill, and Normanskill Shales, eastern New York. Geol. Soc. Amer. Bull. 73:695-718.

__________ and Wilde, P. 1978. Progressive ventilation of the oceans – an explanation for the distribution of Lower Paleozoic black shales. Amer. J. Sci. 278:257-275.

Bird, J.M. 1963. Sedimentary structures in the Taconic sequence rocks of the southern Taconic region. *In* Bird, J.M. (ed.), Stratigraphy, structure, sedimentation, and paleontology of the southern Taconic region, eastern New York. Geol. Soc. Amer. Guidebook for Field Trip 3, Albany, pp. 5-21.

__________ and Dewey, J.F. 1970. Lithosphere plate-continental margin tectonics and the evolution of the Appalachian orogen. Geol. Soc. Amer. Bull. 81:1031-1060.

__________ and Rasetti, F. 1968. Lower, Middle, and Upper Cambrian faunas in the Taconic sequence of eastern New York: Stratigraphic and biostratigraphic significance. Geol. Soc. Amer. Spec. Paper 113, 66 p.

Chapple, W.M. 1973. Taconic orogeny: Abortive subduction of the North American continental plate. Geol. Soc. Amer. Abstracts with Programs 5:573.

__________ 1979. Mechanics of emplacement of the Taconic allochthon during a continental margin-trench collision. Geol. Soc. Amer. Abstracts with Programs 11:7.

Cisne, J., Karig, D., Rabe, B. and Hay, B. 1982. Topography, and tectonics of the Taconic outer trench slope as revealed through gradient analysis of fossil communities. Lethaia 15:229-246.

__________ and Rabe, B. 1978. Coenocorrelation: Gradient analysis of fossil communities and its applications in stratigraphy. Lethaia 11:341-364.

Cushing, H.P. and Ruedemann, R. 1914. Geology of Saratoga Springs and vicinity. New York State Mus. Bull. 169, 177 p.

Epstein, A.G., Epstein, J.B. and Harris, L.D. 1977. Conodont color alteration–An index to organic metamorphism. U. S. Geol. Surv. Prof. Paper 995, 27 p.

Fisher, D.W. 1961. Stratigraphy and structure in the southern Taconics (Rensselaer and Columbia Counties, New York). *In* LaFleur, R.L. (ed.), Guidebook to Field Trips. New York State Geol. Assoc., 33rd Ann. Mtg., Troy, p. D10-D27.

__________ 1962. Correlation of the Ordovician rocks in New York State. New York State Mus. and Sci. Serv. Map and Chart Ser. 3.

__________ 1977. Correlation of the Hadrynian, Cambrian and Ordovician rocks in New York State. New York State Mus. Map and Chart Ser. 25, 75 p.

__________ 1984. Bedrock geology of the Glens Falls-Whitehall region, New York. New York State Mus. Map and Chart Ser. 35, 58 p.

Fortey, R.A., Landing, E. and Skevington, D. 1982. Cambrian-Ordovician boundary in the Cow Head Group, western Newfoundland. *In* Bassett, M.G. and Dean, W.T. (eds.), The Cambrian-Ordovician Boundary: Sections, Fossil Distributions, and Correlations. Natl. Mus. Wales, Geol. Ser. 3, p. 95-129.

Hall, J. 1847. Descriptions of the organic remains of the lower division of the New York System. Palaeontology of New York, Volume 1. C. van Benthuysen Co., Albany, 338 p.

Hesse, R. and Ogunyomi, O. 1982. Cambrian to Lower Ordovician of the Quebec region. *In* Hesse, R., Middleton, G.V. and Rust, B.R. (eds.), Excursion 7B: Paleozoic continental margin sedimentation in the Quebec Appalachians. 11th Int. Cong. on Sedimentol., McMaster Univ., p. 200-230.

Hiscott, R.N., Quinlan, G.M. and Stevens, R.K. 1983. Comment *on* 'Analogous tectonic evolution of the Ordovician foredeeps, southern and central Appalachians'. Geology 11:732.

Jacobi, L.L. 1977. Stratigraphy, depositional environment and structure of the Taconic allochthon, central Washington County, New York. Master's thesis, SUNY at Albany, 191 p.

Jacobi, R.D. 1981. Peripheral bulge–A causal mechanism for the Lower/Middle Ordovician unconformity along the western margin of the northern Appalachians. Earth and Planet. Sci. Letters 56:245-251.

Keith, A. 1932. Stratigraphy and structure of northwestern Vermont. Washington Acad. Sci. J. 22:357-379, 393-406.

Kindle, C.H. and Whittington, H.B. 1958. Stratigraphy of the Cow Head region, western Newfoundland. Geol. Soc. Amer. Bull. 69:315342.

Landing, E. 1976. Early Ordovician (Arenigian) conodont and graptolite biostratigraphy of the Taconic allochthon, eastern New York. J. Paleontol. 50:614-646.

——————— 1988. Cambrian-Ordovician boundary in North America: Revised Tremadocian correlations, unconformities and "glacioeustasy". New York State Mus. Bull. 462.

———————, Barnes, C.R. and Stevens, R.K. 1986. Tempo of earliest Ordovician graptolite faunal succession: Conodont-based correlations from the Tremadocian of Quebec. Can. J. Earth Sci. 24:1928-1949.

——————— and Benus, A.P. 1985. The Levis Formation: Passive margin slope processes and dynamic stratigraphy in the "Western Area." *In* Riva, J. (ed.), Field trips guidebook, 1985 Canadian Paleontology and Biostratigraphy Seminar, Univ. Laval Press, 11 p.

———————, ——————— and Whitney, P.R. *Submitted.* Early and early Middle Ordovician continental slope deposition: cycles and sandstone deposition in the Quebec Reentrant and New York Promontory Region. Canadian J. Earth Sci.

Leggett, J.K. 1978. Eustasy and pelagic regimes in the Iapetus Ocean during the Ordovician and Silurian. Earth and Planet. Sci. Letters 41:163-169.

Lochman, C. 1956. Stratigraphy, paleontology and paleogeography of the *Elliptocephala asaphoides* strata in Cambridge and Hoosick quadrangles, New York. Geol. Soc. Amer. Bull. 67:1331-1396.

Mehrtens, C.J. 1984. Foreland basin sedimentation in the Trenton Group of central New York. 56th Ann. Mtg., New York State Geol. Assoc., Colgate Univ., p. 59-93.

Potter, D.B. 1972. Stratigraphy and structure of the Hoosick Falls area, New York-Vermont, east-central Taconics. New York State Mus. Map and Chart Ser. 19, 71 p.

Quinlan, G. and Beaumont, C. 1984. Appalachian overthrusting, lithospheric flexure and the development of Paleozoic stratigraphy in the eastern interior region, U.S.A. Canadian J. Earth Sci. 21:640-653.

Rasetti, F. 1967. Lower and Middle Cambrian trilobite faunas from the Taconic sequence of New York. Smithsonian Misc. Coll. 152(4), 111 p.

Ratcliffe, N.M. and Bahrami, M. 1976. The Chatham fault: A reinterpretation of the contact relationships between the Giddings Brook and Chatham slices of the Taconic allochthon in New York State. Geology 4:56-60.

Rickard, L.V. and Fisher, D.W. 1973. Middle Ordovician Normanskill Formation, eastern New York: Age, stratigraphic and structural position. Amer. J. Sci. 273:580-590.

Rowley, D.B. and Delano, L.L. 1979. Structural variations in the northern part of the Taconic allochthon. Geol. Soc. Amer. Abstracts with Programs 11:51.

——————— and Kidd, W.S.F. 1981. Stratigraphic relationships and detrital composition of the medial Ordovician flysch of western New England: Implications for the tectonic evolution of the Taconic orogeny. J. Geol. 89:199-218.

———————, ——————— and Delano, L.L. 1979. Detailed stratigraphic and structural features of the Giddings Brook slice of the Taconic allochthon in the Granville area. *In* Friedman, G.F. (ed.), Guidebook for field trips, New York State Geol. Assoc. 51st Ann. Mtg. and New England Intercoll. Geol. Conf. 71st Ann. Mtg., Troy, pp. 186-242.

Ruedemann, R. 1901. Hudson River beds near Albany and their taxonomic equivalents. New York State Mus. Bull. 42:489-596.

——————— 1902. The graptolite (Levis) facies of the Beekmantown formation in Rensselaer County, New York. New York State Mus. Bull. 52:546-575.

——————— 1903. The Cambric *Dictyonema* fauna in the slate belt of eastern New York. New York State Mus. Bull. 69:934-958.

——————— 1912. The Lower Siluric shales of the Mohawk Valley. New York State Mus. Bull. 162:1-145.

——————— 1919. The graptolite zones of the Ordovician shales of New York. New York State Mus. Bull. 227-228:116-130.

——————— 1929. Note on *Oldhamia* (*Murchisonites*) *occidens* (Walcott). New York State Mus. Bull. 281:47-50.

——————— and Cook, J.H. 1914. Geology of the Capital District (Albany, Cohoes, Troy and Schenectady Quadrangles). New York State Mus. Bull. 285, 218 p.

———————, ——————— and Newland, D.H. 1942. Geology of the Catskill and Kaaterskill Quadrangles: Part 1. Cambrian and Ordovician geology of the Catskill Quadrangle. New York State Mus. Bull. 331, 251 p.

——————— and Wilson, T.Y. 1936. Eastern New York Ordovician cherts. Geol. Soc. Amer. Bull. 47:1535-1586.

Seely, D.R., Vail, P.R. and Walton, G.G. 1974. Trench slope model. *In* Burk, C.A. and Drake, C.L. (eds.), The Geology of Continental Slopes, Springer-Verlag, New York, p. 249-260.

Shanmugam, G. and Walker, K.R. 1980. Sedimentation, subsidence, and evolution of a foredeep basin in the Middle Ordovician, southern Appalachians. Amer. J. Sci. 280:479-496.

Stanley, R.S. and Ratcliffe, N.M. 1985. Tectonic synthesis of the Taconian orogeny in western New England. Geol. Soc. Amer. Bull. 96:1227-1250.

Stevens, R.K. 1970. Cambro-Ordovician flysch sedimentation and tectonics in west Newfoundland and their possible bearing on a proto-Atlantic Ocean. *In* Lajoie, J. (ed.), Flysch Sedimentology in North America. Geol. Assoc. Canada Spec. Paper 7, p. 165-178.

Theokritoff, G. 1964. Taconic stratigraphy in northern Washington County, New York. Geol. Soc. Amer. Bull. 75:171-190.

Tucker, M.E. 1973. Sedimentology and diagenesis of Devonian pelagic limestones (Cephalopodenkalk) and associated sediments of the Rhenohercynian Geosyncline, West Germany. N. Jahrb. Geol. Paläontol. Abh. 142:320-350.

Wood, D.S. 1973. Patterns and magnitudes of natural strains in rocks. Phil. Trans. Royal Soc. London, Ser. A 274:373-384.

——————— 1974. Current views of the development of slaty cleavage. Ann. Rev. Earth Planet. Sci. 2:369-401.

Zen, E. 1961. Stratigraphy and structure at the north end of the Taconic Range in west-central Vermont. Geol. Soc. Amer. Bull. 72:293-338.

——————— 1964. Taconic stratigraphic names: Definitions and synonymies. U.S. Geol. Surv. Bull. 1174, 94 p.

——————— 1967. Time and space relationships of the Taconic allochthon and authochthon. Geol. Soc. Amer. Spec. Paper 97, 107 p.

——————— and Hartshorn, J.H. 1966. Geologic map of the Bashbish Falls Quadrangle, Massachusetts, Connecticut and New York. U.S. Geol. Surv. Quad. Map GQ-507, 7 p.

ROAD LOG

Mileage	
0.0	Depart from parking lot on east side of Cultural Education Center, turn right onto Madison Avenue and descend hill. Continue east through intersections with Eagle, Grand, Fulton, Pearl and Green streets.
0.6	Turn right to U.S. Interstate 787 (North).
0.7	Turn left onto Quay Street for access ramp to U.S. Interstate 787 (North).
0.9	Enter access ramp to U.S. Interstate 787 (North).
2.3	Pass access ramp to U.S. Interstate 90.
7.8	City of Troy to east across Hudson River.
8.6	Bear right for access ramp to U.S. Route 7 (West).
11.1-12.1	Pass through long series of cuts in allochthonous(?) Austin Glen Formation (Middle Ordovician synorogenic flysch).
12.1	Bear right to access ramp to U.S. Interstate 87 (North).
14.1	Road cut on right is in Snake Hill/Austin Glen synorogenic flysch.
14.5	Cross Thaddeus Kosciuszko Bridge over Mohawk River (T.K., a Polish national, served on the American side in the Revolutionary War).
20.9	Foothills of the Adirondack Mountains (Grenvillian) are visible to the north.
25.1	Ridge to the northwest is Grenvillian basement uplifted along the Glens Falls fault.
26.6	Note abundant fragments of Snake Hill Formation in cuts through glacial till.
28.5	Begin long descent through cut in shales and sandstones of the Snake Hill Formation.
35.4	Take Exit 14 from Northway (U.S. Interstate 87) to N.Y. Route 29 (East).
35.9	Cross overpass over Northway and continue west.
36.2	Turn right onto access road to Route 29.
37.1	Stop sign and stop light. Turn right onto Route 29(East) to Schuylerville, New York.
41.0	View to east includes "low Taconic" hills and "high Taconics" on skyline.
46.6	Stop light in Village of Schuylerville, turn left onto Routes 4 and 32 (North).
47.3	Enter Town of Northumberland and pass long cut in Austin Glen/Snake Hill facies on left.
47.7	Turn left onto Starks Knob Road (dirt).
47.8	Entrance to quarry at Starks Knob (dirt path).

STOP 1 Starks Knob.

The Starks Knob pillow basalt (Cushing, *In* Cushing and Ruedemann, 1914) is one of the most exotic rock bodies in the Taconic allochthon region. The hill at this locality is composed almost completely of decimeter- to meter-sized pillows of hydrated basalt. The margin of the Taconic allochthon lies just to the east of the Hudson River and Stark's Knob apparently lies under the Taconic master thrust in the "blocks in shale" wildflysch. Careful investigation will show that the top-sense of this pillow basalt is toward the west (based on the convex westerly surfaces of the pillows).

Fine-grained lime mudstone pebbles are caught between and embedded in the pillows. This same type of limestone can be seen to rest in the depressions between the pillows on the crest of Stark's Knob. These limestone lenses at the crest frequently exhibit reddened (western) tops that were heated and recrystallized as the overlying pillows were rolled onto them. The limestones are here proposed to be produced nonbiologically through the sudden loss of carbon dioxide from hot waters that moved through the hot pillow basalt shortly after extrusion. Primary sedimentary structures are limited to horizontal settle-out laminae. The only allochems that have been recognized in the limestones include several trilobite segments in one limestone lens and a macluritid snail suggesting Early or Middle Ordovician age (E. Yochelson, pers. commun., 1982). A fairly exhaustive search for conodonts was made but none were found after the dissolution of samples from 46 limestone lenses.

The pillow basalt lies next to Austin Glen-type flysch (reported as Mount Merino Formation by Fisher, 1977) on the northeast side of the old quarry at the base of the hill. A meter-thick interval of tectonically sheared basalt and sediments lies along this contact.

The presence of a (very) sparse benthic fauna, including a snail, and relatively large size of the calcite-filled amygdules suggest that the pillows were not extruded in the deep water site of Taconic sequence deposition. This extrusive may be a fragment derived from the offshore volcanic arc or, more likely, may have originated with extensional tectonics associated with passage of the peripheral bulge across the site of the old carbonate platform.

48.1	Go back down dirt road and turn left onto Route 4 (North).
48.7	Cross Hudson River and enter Washington County.
50.1	Note remains of old Champlain Canal on right side of road.
54.5	Outcrop of Austin Glen on left.
58.5	Cross steel bridge over Champlain Canal. The Canal diverges from the Hudson River at this point and continues north to Lake Champlain.
58.7	Enter Village of Fort Edward, continue on Route 4.
61.1	Enter Village of Hudson Falls.
61.8	Village green of Hudson Falls, continue north on Route 4.
63.3	Junction with Route 32, continue north on Route 4.
67.0	Enter Village of Kingsbury.
68.8	Tilted blocks to west are easterly dipping surfaces of Grenvillian basement from which the Lower Paleozoic has been eroded.
71.3	Enter Village of Fort Ann.
72.4-74.8	Field trip route passes through a series of cuts in Grenvillian basement.
81.8	Enter Village of Whitehall. The high hill to the northeast is Skene Mountain. The castle-like building is, appropriately, Skene Manor. The second Stop will be at the western base of the hill.
82.4	Stop light, continue on Route 4 (right).
82.8	Stop light, turn left onto Saunders Street.
83.4	Park next to roadcut on east side of Saunders Street.
STOP 2	Autochthonous Upper Cambrian.

The purpose of this stop is to provide a general geological orientation and to illustrate some of the features of the autochthonous sequence of the Lake Champlain Lowlands.

The road cut is in shallow, near-shore deposits of the Potsdam Sandstone (Upper Cambrian). Unconformably underlying Grenvillian basement can be seen on the opposite side of the Champlain Canal in the Village of Whitehall. Herring-bone cross sets, dolomitic quartz arenite pebbles at the base of channels, and *Diplocraterion* burrows all point to tidally-influenced, higher energy deposition of the Potsdam Sandstone. Shallowing upward cycles (interpretable as punctuated aggradational cycles) of meter-scale thickness are recognizable in this transgressive quartz arenite-dominated deposit. The Potsdam Sandstone is overlain by higher Upper Cambrian units (Ticonderoga Formation, dolomitic quartz arenites and quartzose dolostones; and lower part of the Whitehall Formation) on the west face of Skene Mountain.

84.1	Return to intersection with Route 4 and turn left (east) onto Route 4.
84.6	Roadcuts in white weathering, massive dolostones of the Skene Member of the Whitehall Formation (Upper Cambrian).
84.8	Lower portion of roadcut on north side of road is in the Winchell Creek Siltstone Member of the Great Meadows Formation. The Winchell Creek is interpreted as a unit deposited during early Tremadocian (earliest Ordovician) onlap (Landing, 1988). The large (meter-thick) algal buildups at the top of the road cut are in the Fort

	Edward Dolostone Member of the Great Meadows Formation.
85.1	Turn right at Y-intersection onto Washington County Route 18; the hills to the east are underlain by allochthonous rocks of the Taconic allochthon.
86.3	Low outcrop on left is the first exposure (?Truthville Slate) of Taconic sequence rocks along this route.
86.8	Small road cut of Bomoseen feldspathic arenite on left.
87.4	Cut in Bomoseen.
88.1	Crossroad and stop sign in hamlet of East Whitehall, turn right (south).
88.1	Beginning of long cut in Hatch Hill Formation on east (left) side of road.
88.6	Begin descent into small creek valley.
89.0	Road cuts in Hatch Hill Formation on right.
89.6	Pass intersection with Dunbar Road (on right) and note cut in red slates and cherts in the Indian River Formation on east side of Dunbar Road.
89.9	Y-intersection with Holcombville Road, turn right and immediately ascend hill on Holcombville Road (south).
90.9	Turn left (east) onto private dirt road on east side of Browns Pond. Park and walk past house to end of dirt road, outcrops in woods at end of the road.
STOP 3	Lower part of the Browns Pond Formation type section.

The thick-bedded, white weathering quartz arenite (ca. 7m thick) represents the (channelized or sheet sand) Mudd Pond Quartzite facies that occurs near the base of the Browns Pond Formation. Black shales on the slope that descends to the swamp to the east are the lowest part of the Browns Pond Formation. The Truthville Slate is exposed on both sides of the swamp.

On the walk back west, note low exposures of orange weathering, dolomitic black slate in dirt road. As the dirt track descends to the west (up section), note exposure of a second Mudd Pond-type quartzite and (higher) crops of "Black Patch Grit", a shale clast, muddy matrix debris flow-type facies.

The top of the Browns Pond Formation lies just east of Holcombville Road. A small green slate outcrop of the Middle Granville Formation is present near the road side.

An idea of the thickness of the Taconic sequence may be obtained by looking toward the main ridge crest west of Browns Pond. The overturned, easterly dipping section that we have investigated continues to the ridge crest where the Austin Glen Formation occupies a synclinal axis.

91.1	Return to Holcombville Road and turn left (south).
91.2	Stop at north end of cuts on both sides of road.
STOP 4	Upper part of the Browns Pond Formation and overlying Middle Granville Formation.

Dolomitic, dark grey, fine-grained sandstones and slates on the east side of the road cut are associated with thin (decimeter-thick), lensing, sandstone pebble debris flows. Small cross beds in the dolomitic quartz arenites demonstrate that this section is overturned. Centimeter-wide, meandering, grazing trails are present on the top of some of the sandstones.

The west side of the road cut is a thick, limestone pebble- to boulder-clast debris flow. Trilobites, archaeocyathid fragments, molluscs and phosphatic problematica of the *Elliptocephala asaphoides* fauna may be recovered from the slope limestone clasts at this locality (see Theokritoff, 1964). Debris flows of this type and bedded limestones are characteristic of the upper part of the Browns Pond Formation.

The overlying Middle Granville Formation will be examined from discontinuous pasture outcrops of green slate in a walk west to the shore of Browns Pond. Bedded limestones and debris flows that occur elsewhere in the lower and middle portion of the Middle Granville Formation have not been observed in this section. However, the lowest part of the overlying Hatch Hill Formation crops out as black shales, nodular (diagenetic) thin microsparites, and a microsparite pebble clast debris apron on the shore of the lake.

91.2	Return to Holcombville Road and continue south.
91.9	Turn right (west) on Tanner Hill Road and drive uphill.
92.1	Park at turn-off at base of long road cut.
STOP 5	Hatch Hill, Deep Kill, Indian River and Mount Merino Formations.

The Tanner Hill section, as the previous two stops, are superb localities that were first described by Rowley, Kidd and Delano (1979). Our walk up hill continues an examination of the Taconic sequence from the west limb of a large overturned syncline.

The thick, coarse-grained, dolomitic quartz arenites in the lower part of this section are characteristic of the Hatch Hill Formation. These lensing (apparently channelized) conglomeratic sands become thinner bedded higher in the section and black shales become more prominent. These sands disappear and black shales form the uppermost Hatch Hill in the section. No fossils have been recovered at present from the Hatch Hill at this locality.

Black shales are abruptly overlain by grey-green silty slate of the Deep Kill Formation near the dirt road that cuts north from Tanner Hill Road. Very thin dark grey shale layers occur in the Deep Kill but the major black shale-limestone intervals that occur elsewhere in the formation do not appear in this section.

The abrupt transition between the greenish Deep Kill and overlying, red Indian River Formation takes place in a meter-thick interval that is poorly exposed on the north side of the road. The best outcrops of the Indian River Formation are present on the west limb of the syncline and thin greenish quartz arenites and burrow mottles may be seen where the road turns northwest and trends obliquely to the synclinal axis.

A relatively complete section through the Mount Merino Formation is present along the north side of the road and opposite the old slate quarry to the south. The Mount Merino is a darker green than the Deep Kill in this section and has more numerous thin quartz arenites. The dark graptoliferous shales of the Mount Merino are not present in this section.

92.3	Return to Holcombville Road and turn right (south).
92.9	Pass quarries and hillocks of scrap slate from the Middle Granville Formation, note sea-green and purplish colors of rock.
93.6	Turn right at intersection with DeKalb Road.
94.4	Stop sign at T-intersection with Truthville Road, turn left (south).
95.5	Stop sign and intersection with Middleton Road, continue south on Truthville Road.
95.7	Stop sign at intersection with Washington County Route 12, turn right onto Route 12.
96.0	Intersection with New York Route 22, park near stop sign and walk east on Route 22.
STOP 6	Contact of the Bomoseen and Truthville facies.

This brief stop introduces two units from the Lower Cambrian(?) of the Taconic sequence. Participants will probably note the similarity between the dark grey-green, matrix-rich, feldspathic quartz arenites of the Bomoseen with portions of the Charney Group near Quebec City. Bedding is difficult to recognize in the massive Bomoseen at this locality. A meter-long sandstone dike and mud-matrix slumps are present near the western end of the road cut on the north side of Route 22. The transition from the Bomoseen into the Truthville features abrupt decrease in sand availability.

96.0	Return to intersection, turn right (west) on Route 22.
96.4	Enter Village of North Granville.
97.8	Turn left (south) onto Route 40, our route to the south along this road will parallel the western margin of the Taconic allochthon.
112.5	Enter Village of North Argyle.
113.3	Enter Village of Argyle.
113.6	Stop sign at intersection, turn left in order to follow Route 40 (South).
117.4	Enter Village of South Argyle.
119.3	Enter Town of Greenwich.
122.5	Turn right onto Bald Mountain Road (paved).
123.5	Follow road to western face of Bald Mountain, take right fork at Y-intersection.
123.7	Park in front of dirt road leading east into Bald Mountain Quarry.
STOP 7	Bald Mountain Quarry.

This locality is essentially identical to Stop 1 in that it illustrates the "blocks in shale" facies at the sole of the master thrust of the Taconic allochthon. The Bald Mountain limestone block is part of an eight kilometer-long belt of carbonate blocks that crop out locally along the leading edge of the allochthon. Dark Lower Cambrian slate lies at the top of the high wall of the quarry while the Bald Mountain limestone block rests within the Middle Ordovician "blocks in shale" facies. Pebbles and boulders of limestone and Taconic sequence lithologies are present in a chaotic mixture in outcrops just below (west) the high quarry wall. The Bald Mountain limestone block is about 30 m thick and consists of a massive fossil wackestone with Lower Ordovician (upper Canadian) cephalopods and snails as the dominant faunal elements. The block lithically and faunally resembles the autochthonous Fort Cassin Formation.

123.7	Return to Route 40.
125.0	Turn right (south) and continue on Route 40.
126.0	Stop sign and intersection with Route 29, turn right (west) and continue on combined Route 29-40.

126.6	Enter Town of Easton and cross Battenkill River.
127.1	Turn left onto Route 40(South).
129.7	Pass road cuts in Trenton Limestone (Middle Ordovician) at the leading edge of the Taconic allochthon.
138.3	Enter Rensselaer County.
141.0	Enter Village of Schaghticoke.
141.8	Cross bridge over the Hoosick River. The type locality of the "Schaghticoke Shale" (here referred to the lower part of the Deep Kill Formation) and its classic Tremadocian graptolite faunas (Ruedemann, 1903) occurs in the rocky gorge below the bridge. The locality is a large block lying at the sole of the Taconic master thrust.
146.0	Enter Village of Melrose.
146.8	Turn left onto Grant Hollow Road.
147.0	Park in hamlet of Grant Hollow and follow paths east along the Deep Kill.

STOP 8 Type section of the Deep Kill Formation (DO NOT DAMAGE THIS LOCALITY!).

The classic Arenigian graptolite localities at the Deep Kill occur in slices at the sole of the Taconic master thrust. The crest of Rice Mountain to the southeast of the upper fault block of the Deep Kill Formation is composed of Lower Cambrian slates.

The lower 16 m of the lower part of the Deep Kill section were assigned by Berry (1962) to his *Tetragraptus fruticosus* and *Didymograptus "protobifidus"* Zones and represent the middle Arenigian black shale-limestone interval that is extensive in Taconian slope facies in eastern New York and Quebec (Landing, Benus and Whitney, *Submitted*). The upper part of the lower Deep Kill section is dominated by green-grey mudstones of Berry's (1962) *Didymograptus bifidus* Zone. The entire lower part of the Deep Kill Formation at its type locality has *Prioniodus evae* Zone conodonts (Landing, 1976).

A long (ca. 275 m) interval along the Deep Kill is covered further to the east, and outcrops appear only at the spillway of the small reservoir on the upper Deep Kill. Tectonically sheared but graptoliferous slates of the Mount Merino Formation lie at the base of the spillway and are overthrust by the upper part of the Deep Kill Formation. The lower 3.5 m of the Deep Kill above the thrust fault contact with the Mount Merino represent the upper Arenigian (lower Whiterockian) (Landing, 1976) black shale-limestone interval in the Quebec and New York Taconian allochthons (Landing, Benus and Whitney, *Submitted*). These dark colored beds are succeeded by green shales in the upper portion of the spillway. The Mount Merino reappears east of the dam on the north side of the reservoir.

147.0	Return to Grant Hollow and continue south on Grant Hollow Road.
147.2	Intersection with Route 40, turn left (south).
148.7	Enter Village of Speigletown.
150.6	Enter City of Troy.
150.7	Turn right at stop light to continue on Route 40 (South).
150.8	Turn left at stop light, continue on Route 40 (South).
154.3	Intersection with Route 7, turn right (west) on Route 7.
154.8	Cross Hudson River and enter Albany County.
155.0	Take access ramp to U.S. Interstate 787 (South).
160.8	Intersection with U.S. Interstate 90, continue south.
162.8	Pass access ramp to U.S. Route 9 (South) and 20 (East).
162.8-171.1	Pass access ramps to U.S. Route 9 and 20, the Empire State Plaza and Cultural Education Center lie at the top of the hill to the west (right).
171.7	Bear right on access road to exit for the Port of Albany and South Pearl Street (Route 32).
172.1	Stop light at intersection with South Pearl Street, turn left (south) on South Pearl.
172.2	Pass under U.S. Interstate 787 overpass.
172.6	Bear right (south-southwest) at stop light and enter dead-end street.
172.8	Park at end of dead-end street, ascend foot path to railroad tracks, and walk west to railroad cuts.

STOP 9 Type area of the Normanskill.

The railroad cut lies on the north side of the Normans Kill and exposes a highly sheared section in dm- to m-thick turbidite sands with shale pebble clasts and dark grey to black shales of the Austin Glen-type facies. The locality is near Hall's (1847; Ruedemann, 1901) classic locality at Kenwood. More recently, Berry (1962) reported specimens of the middle Caradocian species *Dicellograptus divaricatus* (Hall) and *D. divaricatus bicurvatus* Ruedemann from the cut, and specimens may be found in the shale scree above the tracks. Sedimentary structures include flutes, tool marks, load casts and flames, and rippled surfaces at the base of some of the rusty-weathering sands. The locality lies across the river from the leading edge of the Taconic allochthon and could represent a giant block in the "blocks in shale" wildflysch or a tectonized fragment of (?par)autochthonous synorogenic flysch.

172.8 Return to vehicles, end of field trip.

Upper Silurian to Middle Devonian Stratigraphy and Depositional Controls, East-Central New York

Edwin J. Anderson[1], Carlton E. Brett[2], Donald W. Fisher[3], Peter W. Goodwin[1], Gerry J. Kloc[2], Ed Landing[4], and Richard H. Lindemann[5]

---

[1] Department of Geology, Temple University
[2] Department of Geological Sciences, The University of Rochester
[3] 1 Lindenwald Court, Kinderhook
[4] New York State Geological Survey, The State Education Department
[5] Department of Geology, Skidmore College

SUMMARY (EL)

The field trip is designed to provide an overview of the stratigraphy, paleoenvironments, and depositional controls of the uppermost Silurian through the Middle Devonian in the essentially flat-lying terrane to the southwest of Albany, New York. Several topics will be emphasized on the trip: (1)The uppermost Silurian through lower Lower Devonian (Helderberg Group) represents a natural lithological grouping as a long-term transgressive-regressive cycle. All major facies (formations and members) are significantly time-transgressive and most fossils are facies-associated in the Helderberg Group. However, Helderbergian stratigraphy appears to be divisible into meter-scale, sharply bounded, shoaling upward cycles that are regionally extensive between major facies belts. These shoaling upward cycles are a type of punctuated aggradational cycle (PAC) that results from geologically instantaneous deepening followed by aggradation to base level. PAC's offer the potential of finely resolved time correlation. (2)The upper Lower Devonian (Tristates Group: Oriskany-Esopus-Carlisle Center-Schoharie) represents, or at least has the characters of a major transgressive-regressive couplet. (3)The base of the Middle Devonian (Onondaga Limestone), as in many other regions of eastern and midwestern North America, is disconformable with underlying units and represents a significant unconformity within the Kaskaskia Sequence. The Onondaga Limestone represents, from base to top, a progressively deepening sequence with analogues to the Helderberg Group: Edgecliff Member (with reefs) =Coeymans, Nedrow + Moorehouse=Kalkberg, Seneca=New Scotland). (4)Onondaga Limestone (Seneca) deposition is followed by the progressive westerly flood of clastics from the rising Acadian mountain building interval. The initial siliciclastics of the marine Hamilton Group are black shales of the lower part of the Marcellus Formation that reflect widespread anoxic bottom waters. A short term regressive event during the lower portion of the Marcellus is recorded by the Cherry Valley Limestone and related carbonates. Continued siliciclastic deposition and accumulation of the earlier portion of the Hamilton Group allowed aggradation and shoaling that permitted the appearance of diverse benthic faunas in the Mount Marion Formation (upper Marcellus equivalent). The Mount Marion also shows near-shore depositional features on the seaward margin of rivers draining the rising Acadian highlands to the east.

INTRODUCTION (EL)

The area of the field trip lies on the northeastern margin of the Allegheny Plateau (Figure 1). Silurian and Devonian units are essentially unaffected by Acadian and Alleghenian tectonism (see, however, Stop 3) and dip gently toward the south-southwest into the Appalachian Basin. These Middle Paleozoic units rise as an escarpment and low range of mountains above the Mohawk River Valley lowlands to the north. The underlying Middle to Upper Ordovician siliciclastics (Schenectady and Frankfort shales and sandstones) are more readily eroded than the Helderberg and Onondaga carbonates that form escarpments in the region. The rounded hills to the south of the Onondaga Escarpment are underlain by shales and thin bedded sandstones of the Marcellus Formation and may be regarded as foothills of the Catskill Mountains to the south.

PRE-DEVONIAN STRATIGRAPHY (DWF, EL)

Directly beneath the Early Devonian Manlius strata of this region are the Late Silurian Rondout and Brayman Formations, respectively. The Rondout is divisible into an upper Chrysler Dolostone Member and a lower Cobleskill Limestone Member; the two are vertically gradational. The Cobleskill contains diagnostic Late Silurian fossils, foremost of which is the "chain" coral *Cystihalysites*. Relatively high energy environments are indicated by circumrotational (e.g. "cannonball") stromatoporoids in the Cobleskill Limestone at Stop 7. The Chrysler has not yielded diagnostic fossils for age

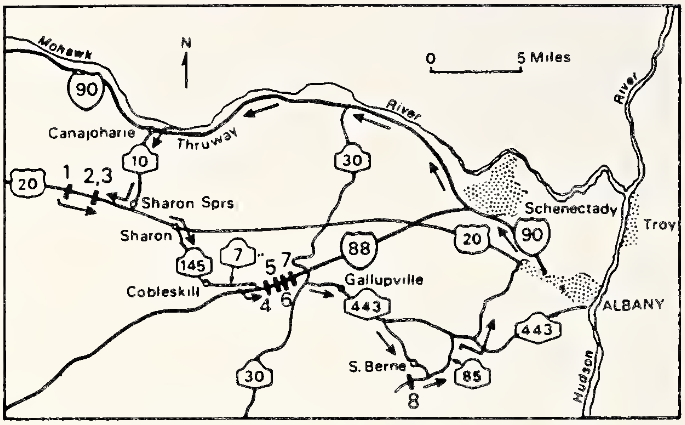


Figure 1 Generalized localities of field trip.

determination, and it is uncertain whether this unit in the field trip area should be referred to the latest Silurian or earliest Devonian. It is placed in the uppermost Silurian in Figure 2. The underlying Brayman Shale has yielded Late Silurian fossils, (Fisher and Rickard, 1953, p.8) establishing a Pridolian age. Except for the subtidal coral-bearing rocks, these Upper Silurian units were formed in shallow hypersaline waters largely within the supratidal and intertidal zones.

North from the Cherry Valley region (Stops 1, 2), Upper Silurian strata rest unconformably on peneplained Upper Ordovician Frankfort gray shales and argillaceous siltstones which, in turn, rest on Utica black shale. Successively beneath the Utica are thin Middle Ordovician Trenton and Black River limestones. These limestones (not everywhere the same) rest unconformably on Lower Ordovician Tribes Hill dolostones and dolomitic limestones and the Upper Cambrian to lowest Ordovician Little Falls Dolostone. Unconformably beneath these Early Paleozoic strata are Proterozoic rocks metamorphosed during the Grenville Orogeny 1,100-975 million years ago. The Cambrian and Ordovician carbonates represent shallow water supratidal, intertidal, and subtidal deposits on an ancient continental shelf; the Ordovician pelites are basinal deposits formed some 450 million years ago, on this downwarped shelf during the Taconic Orogeny. About 450 m (ca. 1500 ft) of Ordovician and Cambrian strata lie between the Silurian and Proterozoic rocks.

HELDERBERG GROUP STRATIGRAPHY (DWF, EL)

Manlius Limestone

The Manlius Limestone contains several members along its outcrop belt from Port Jervis to Manlius, Onondaga County. In the Cherry Valley area, the Thacher Member (Rickard, 1962, p. 43-54) enters from the east as a basal unit.

The Thacher Limestone is a very light gray to white weathering, dark gray to black, thin to thick bedded, fine to medium-grained limestone with rare calcareous shale interbeds and rare crossbedding in a few coarser beds. The thin bedded lime mudstones (ribbon limestones) and blocky, medium bedded layers break with a conchoidal fracture. Fossils are abundant but only a few species are represented. Stromatoporoid reefs and baffles are locally present at the top of the Thacher Member. The tentaculitid *Tentaculites gyracanthus* and the ostracode *Hermannina alta* are ubiquitous in the ribbon strata, together with rare edrioasteroids (*Postibula* n.sp.), scarce bryozoans, and common spiriferid brachiopods (*Howellella vanuxemi*); low- and high-spired gastropods are more common in the reefs and baffles.

The Thacher represents at least three different environments each characterized by specific physical and organic traits; supratidal, intertidal, and proximal subtidal. Clearing of marine waters from the hypersaline Rondout sea permitted a more diverse and abundant life to pervade the Manlius sea.

Coeymans Limestone

The Coeymans Limestone is a medium- to thick-bedded, medium to coarse-grained, fossil fragment limestone. Bedding contacts are irregular and stylolitic. The formation has a moderately diverse fauna characterized by the pentamerid brachiopod *Gypidula coeymansis*, meristellid and uncinulid brachipods, and crinoidal and cystoidal debris. The westwardly thickening Coeymans (Ravena Member-Rickard, 1962, p. 65-68) splits along the Judd's Falls Valley into a lower Dayville (Rickard, 1962, p. 68-72) Limestone and an upper Deansboro (Rickard, 1962, p. 72-77) Limestone, separated by a tongue of Manlius lithology.

The Coeymans seems to have been deposited on the seaward side of fringing stromatoporoid barriers and baffles in agitated, clear, shallow water with an abundant "pelmatozoan" fauna.

Kalkberg Limestone

The Kalkberg (Chadwick, 1908) is a light- to medium-grey weathering, medium to dark grey colored, thin to medium bedded limestone. The unit consists of fine to medium-grained, siliceous limestone with calcareous shale interbeds. Dark grey to black chert pods and beds are characteristic. A 2-3 cm-thick volcanic ash occurs along the south side of U.S. Route 20 at the overpass for the abandoned Cherry Valley Railroad. This ash has been radiometrically dated (Rb-Sr) at 395 million years (Miller and Senechal, 1965). The Kalkberg contains abundant, diverse fossils that include brachiopods, bryozoans, and crinoid columnals. The unit accumulated in a relatively low energy subtidal environment

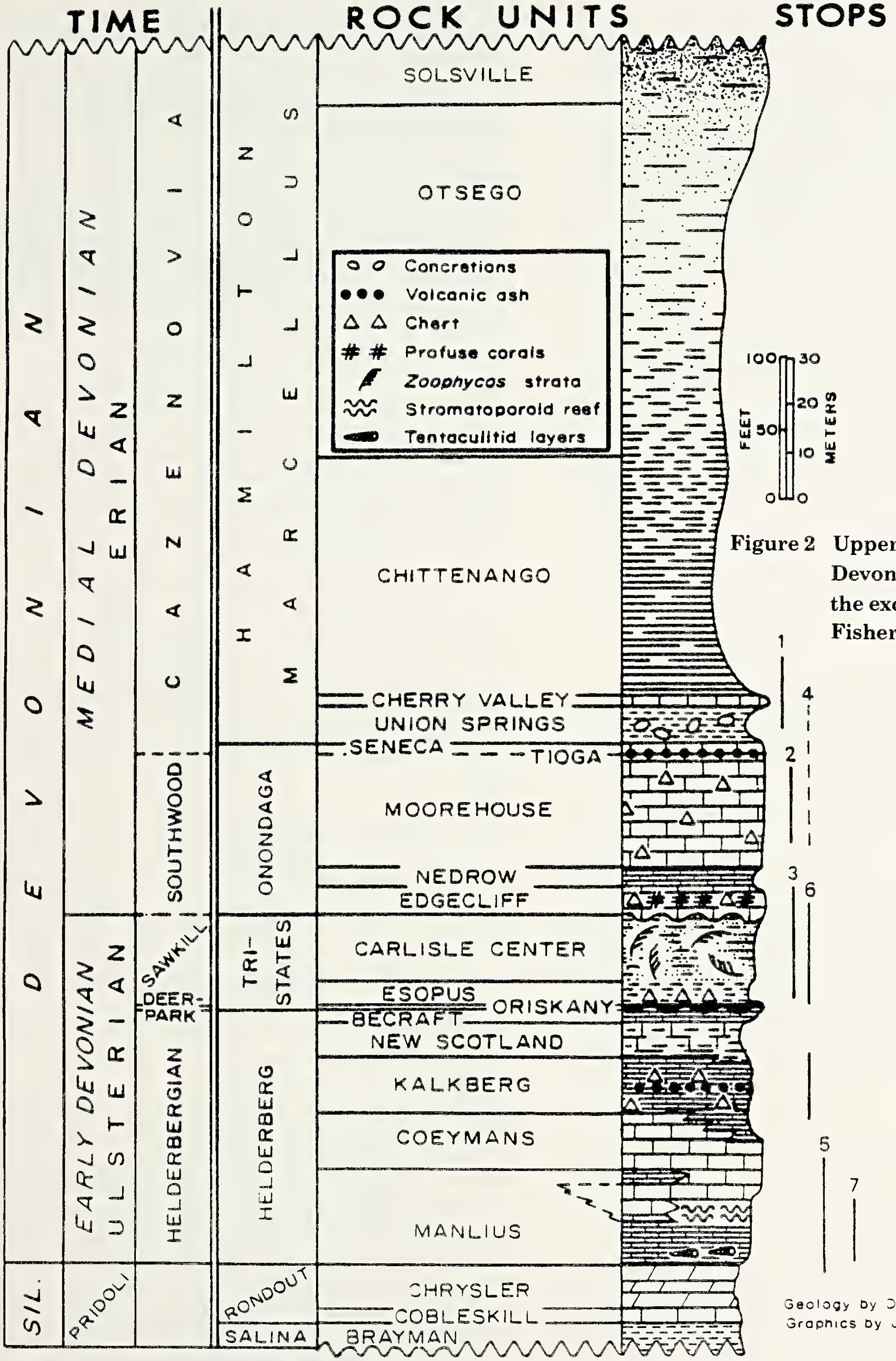


Figure 2 Upper Silurian to Middle Devonian stratigraphy of the excursion area (from Fisher, 1979).

Geology by Donald W Fisher
Graphics by John B Skiba 2/79

but lenticular fossil grainstones are evidence for the influence of storm waves.

New Scotland Limestone

The New Scotland Limestone is a thin-bedded, dark grey to brown argillaceous lime wackestone to packstone interbedded with calcareous shales. At times, especially in the Hudson River Valley, these calcareous-rich and more argillaceous-rich layers succeed each other in dm-thick cyclical (ABAB) alternations. A brownish weathering color is common and reflects the relatively high content of framboidal pyrite. The New Scotland is the most fossiliferous unit in the Helderberg Group and has diverse fauna of brachiopods, bryozoans, trilobites, rugosans and disarticulated crinoids. In this region, the New Scotland is poorly exposed beneath the overlying Becraft terrace. The most westerly exposure of the New Scotland is at the top of the U.S. Route 20 roadcut at the western edge of Sharon Springs, and the unit is absent at Cherry Valley. The New Scotland represents more distal and deeper water environments than the Kalkberg. These units are obvious lateral equivalents and the New Scotland-type facies may be seen at the U.S. Interstate 88 cut (Stop 5) intercalated within the Kalkberg.

Becraft Limestone

The highest division of the Helderberg Group in the southern portion of the Canajoharie 15-minute Quadrangle is the Becraft Limestone. The unit is a medium grey weathering, light grey to tan colored, medium to thick bedded, coarse-grained echinoderm grainstone. It is dominated by crinoid columnals and characterized by the shield-like crinoid holdfast *Aspidocrinus scutteliformis*. Uncinulid brachiopods are also common. The Becraft is absent at Cherry Valley but appears further east at Sharon Center. It forms a conspicuous ledge and terrace southeast of Sharon (Stop 5) and continues along the Helderberg escarpment to Thacher Park and southward to Kingston. Its lithology and the prominence of crinoid debris is comparable to that of the Coeymans and the two units represent high energy echinoderm shoal environments.

Alsen and Port Ewen Limestones

These higher units of the Helderberg Group are not present in the Cherry Valley or Sharon areas. The cherty Alsen Limestone appears to the east in the Schoharie Valley and continues east and south along the Hudson River Valley. The argillaceous Port Ewen Limestone appears further south in the Hudson River Valley near Coxsackie and is thickest in the Kingston area of the Hudson Valley. These units are similar to those of the Kalkberg and New Scotland, respectively, and represent a deepening cycle in the uppermost Helderberg Group.

HELDERBERG FACIES AND PUNCTUATED AGGRADATIONAL CYCLES (EJA, PWG)

Hypothesis of Punctuated Aggradational Cycles

The Hypothesis of Punctuated Aggradational Cycles (Goodwin and Anderson, 1985) is a comprehensive stratigraphic model which states that most stratigraphic accumulation occurs episodically as thin (1-5

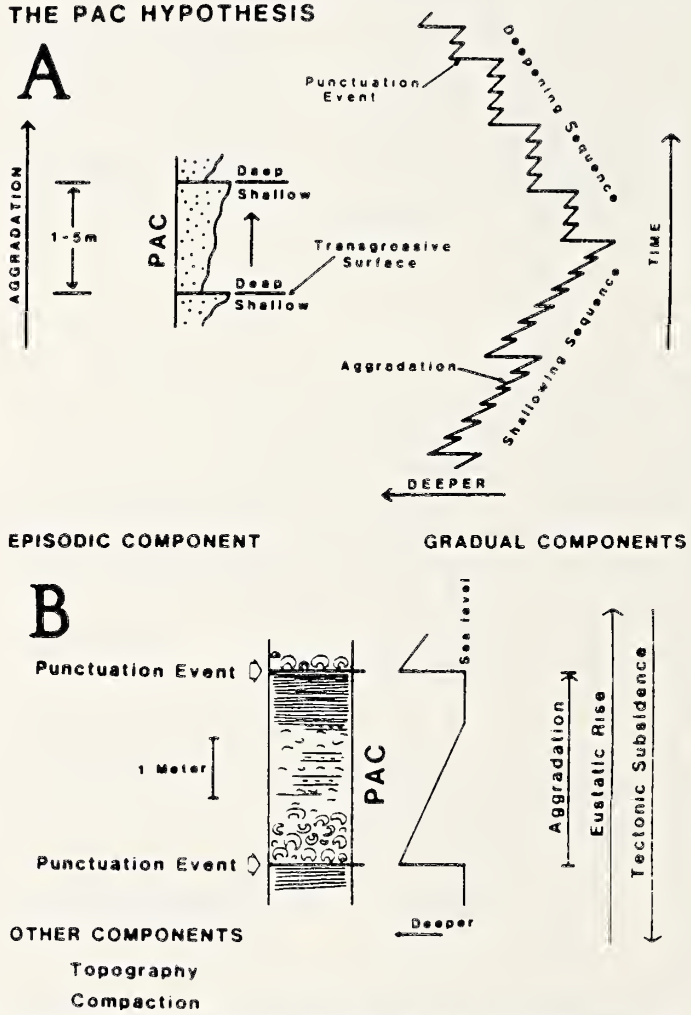


Figure 3 A. General model of the Hypothesis of Punctuated Aggradational Cycles. Each PAC is bounded by surfaces of abrupt change to deeper facies. Facies changes within a PAC are gradational. At a larger scale, shallowing and deepening sequences consist entirely of PACs produced during periods of aggradation punctuated by deepening events. B. Analysis of the dynamics involved in the development of a PAC.

meters thick) shallowing-upward cycles (PACs) separated by surfaces of abrupt change to deeper and environmentally disjunct facies (Figure 3). These surfaces are created by geologically instantaneous, basin-wide, relative base-level rises; deposition occurs during the intervening periods of relative base-level stability. Base-level fluctuations occur with periodicities in the Milankovitch band and thus result in a small-scale pattern of allogenic cycles that provide a genetic framework for paleoenvironmental interpretation and detailed basinwide physical event correlation.

A basic tenet of the PAC hypothesis is that the shallowing-upward motif on the scale of a few meters of thickness is pervasive throughout the stratigraphic record. The hypothesis predicts that PACs exist in rocks representing all environments in which a rapid base-level rise can directly or indirectly influence depositional processes. Thus, fluvial, deltaic, tidal, shelf, slope, turbiditic fan, and basinal clastic environments as well as the full spectrum of marine carbonate environments should produce deposits that display the PAC motif. Not only are PACs expected in all sedimentary environments, but PACs are also basinwide rock units that may be traced laterally through the deposits of a variety of co-existing environments. Theoretically, PACs terminate at the lateral limit of all contiguous depositional sites affected by a specific position of sea-level. Therefore, a particular PAC will be defined by different sedimentologic evidence at different places in the basin. A new and different environmental spectrum is created by each deepening event and modified by aggradation during periods of base-level stability (Goodwin and Anderson, 1985).

The thickness of carbonate cycles such as PACs is dependent on the interaction of a number of variables. From analyses of facies within PACs (Figure 3 B) we are able to demonstrate that PAC thickness and thickness of facies within PACs are also dependent on the magnitude of punctuation events, topography inherited from the previous cycle, environmentally controlled sedimentation rates and gradual base-level change either from tectonic subsidence or eustasy. Given adequate sedimentation rates, thick PACs will be produced following large punctuation events. Gradual base-level rise produces over-thickened facies within PACs because sedimentation keeps pace with subsidence or eustatic rise. PACs will be thinner over inherited topographic highs and thicker over low-areas. In all cases, supply of sediment is a factor in PAC thickness; in deeper environments of low carbonate productivity PACs tend to be thin. These and other variables have been incorporated in computer modeling of synthetic carbonate cycles (Read and others,1986). In these experiments Read and others have demonstrated that thickness and facies structure in synthetic cycles can be determined by amplitude and period of sea-level fluctuation, lag time, sedimentation rates and subsidence.

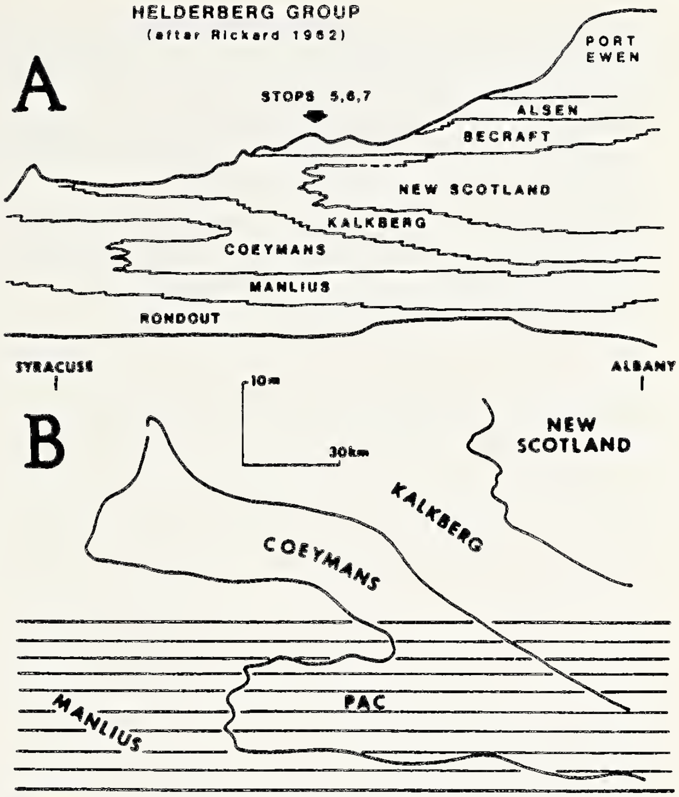


Figure 4 **A. East-west cross-section of formations in the Helderberg Group. B. Conceptual relationship between PACs and Helderberg stratigraphy. PACs are thin time-stratigraphic units which cut across major facies (generally diachronous formations). For simplicity, PACs are illustrated schematically only in the lower portion of the cross-section.**

We hypothesize that the punctuation events which produce PACs are geologically instantaneous and at least basin-wide in their influence. Very rapid deepening events are indicated by sharp surfaces of non-deposition at PAC boundaries and by the absence of gradationally deepening-upward cycles. The basin-wide influence of punctuation events is indicated by the lateral persistence of PACs for tens of kilometers across the Helderberg basin and by the traceability of PAC sequences throughout the basin.

In summary, the essential elements of the PAC Hypothesis are:

1. The basic stratigraphic motif is the small-scale shallowing-upward cycle (PAC) separated by sharply defined non-depositional surfaces.
2. PACs are produced by frequent (every 20-100 thousand years), geological instantaneous, base-level rises (punctuation events) which are at least basin-wide.

3. PACs are theoretically traceable throughout a basin of deposition as time-stratigraphic units bounded by synchronous surfaces.
4. PACs are the fundamental rock units for stratigraphic, paleoenvironmental and paleoecologic analysis.
5. As mappable rock units which are also time-stratigraphic, PACs offer unequalled opportunity for establishing basin-wide chronologic correlations and paleogeographic reconstructions.

Finally, stratigraphic analysis conducted under the assumptions of an episodic allogenic model, such as the PAC hypothesis, are fundamentally in conflict with studies using traditional methods (Goodwin *et al.*, 1986). Traditional analyses which assume gradual stratigraphic accumulation and autocyclicity lead inevitably to the employment of members and formations as the units of description and interpretation. Such studies apply Walther's Law and assume that formations can be equated with paleoenvironmental bands that existed in continuity and migrated with time to produce large-scale transgressive-regressive sequences.

In contrast, assumption of a model like the PAC hypothesis leads to field description, correlation and paleoenvironmental interpretation in terms of small-scale cycles (Figure 4). Formations and members no longer are fundamental units of description and interpretation. In turn the "superimposed primarily" constraint of Walther's Law can be shown not to be met. Thus, interpretations of thick stratigraphic sequences such as the Helderberg Group as simple transgressive or regressive sequences are invalid. Instead, application of the PAC hypothesis reveals that the Helderberg Group is a complex hierarchy of allogenic cycles.

PACs and Helderberg Stratigraphy

Detailed stratigraphic relationships of the Helderberg Group of New York State, were established by Rickard (1962) from a series of approximately 160 closely spaced localities along the outcrop belts in the Hudson Valley and in the Mohawk Valley (Figure 4A). Using this stratigraphic framework, Laporte (1967) and Anderson (1972) developed paleoenvironmental interpretations of Manlius and Coeymans facies, thereby establishing the basic paleogeographic setting of the Helderberg Basin. Based on this stratigraphic framework, Rickard (1962) and Laporte (1969) interpreted the Helderberg Group as a transgressive carbonate sequence representing a spectrum of paleoenvironments including tidal flat (Manlius Formation), shallow shelf (Coeymans Formation) and deep shelf (Kalkberg and New Scotland Formations) facies. This interpretation of the Helderberg Group as a transgressive sequence was built on the assumption that each successive Helderbergian formation represented a deeper or more off-shore paleoenvironment and that these paleoenvironments migrated westward across New York State in response to gradual base-level rise.

More recently Goodwin and Anderson (1985) have developed the PAC hypothesis and applied it to the Helderberg Group. Analyzing the Helderberg Group from an episodic perspective leads to correlation of thin stratigraphic units throughout, reinterpretation of the stratigraphic dynamics that produce formational boundaries and a different concept of the relationship between Helderbergian stratigraphic units and their depositional environments. The PAC hypothesis predicts that the Helderberg Group is totally divisible into small-scale, time-stratigraphic, shallowing-upward cycles that cut across major facies generally mapped as diachronous formations (Figure 4B). Each PAC is bounded by sharp surfaces separating facies representing noncontiguous environments. Therefore, each PAC boundary is a significant paleoenvironmental discontinuity which can be traced laterally from one diachronous formation (e.g. Coeymans) into contemporaneous facies mapped as other formations (e.g. Manlius to the west and Kalkberg to the east). At single localities, formation boundaries generally coincide with PAC boundaries (Anderson, Goodwin and Sobieski, 1984). Therefore, these formation boundaries are discontinuities separating environmentally disjunct facies which were superimposed episodically, not gradually (Figures 5 and 6).

Adoption of the PAC as the fundamental unit of description and interpretation has led to paleoenvironmental analysis very different from earlier interpretations of the Helderberg Group (Rickard, 1962; Laporte, 1967; Anderson, 1972). For example, the Manlius Formation, previously interpreted as a disordered mosaic of peritidal facies (Laporte, 1967) is now viewed as a highly ordered sequence of time-stratigraphic cycles (PACs), each representing a discrete paleoenvironmental spectrum (Goodwin *et al.*, 1986). Within each PAC, facies change gradually both laterally and vertically; across PAC boundaries facies changes are abrupt and environmentally disjunct. Therefore, Walther's Law is applicable within PACs but not across PAC boundaries.

At a larger scale the Helderberg Group is not a continuous transgressive sequence but a structured sequence of small-scale basin-wide allogenic cycles which can in turn be grouped into large-scale PAC sequences. Most formational boundaries are produced by major deepening events which set off these larger-scale cyclic units. For example, the Rondout Formation at Schoharie (Figure 5) is a shallowing PAC sequence initiated by the Cobleskill event and terminated by a major punctuation event at the Rondout-Manlius boundary.

Paleontological Implications of PACs

Acccumulation of the stratigraphic record in small-scale allogenic cycles directly and profoundly affects the distribution of fossil organisms. First, puncuation events disrupt deposition in all paleoenvironments. These events commonly eliminate habitats and initiate new paleoenvironments which are then occupied by different species. The deepest lithofacies of a PAC typically occurs just above the lower PAC boundary and usually contains the most diverse biofacies in the PAC. Aggradational shallowing, often accompanied by paleoenvironmental restriction leads to decrease in faunal diversity and change in faunal composition upward through the PAC. Major faunal changes occur in response to punctuation events of large magnitude. Key species or faunal associations are often restricted to a single PAC or to a small group of similar PACs.

Special paleoecologic conditions occur as a consequence of punctuation events at PAC boundaries. These events disrupted the process of carbonate production or clastic input thereby creating a drowned surface of temporary non-deposition. Such surfaces (often hardgrounds) provide unique clear-water habitats for encrusting and mound-building organisms.

Given a punctuated stratigraphic record, autogenic ecologic succession would appear to be a useful concept only at the scale of single beds or on hardgrounds. Within PACs, succession of species is only a reflection of continual modification of the physical environment by aggradation and gradual base-level change (allogenic succession?). Perhaps only within PACs containing reefal accumulations is true ecologic succession recorded at a scale larger than a single bed.

Finally, punctuation events (especially those of large magnitude) are thought by us to play a possibly significant role in evolution. Acting with a periodicity of 10^4-10^5 years these synchronous events may well have caused intensification of both Darwinian natural selection and species selection and also may have been an agent causing extinctions (see also House, 1985).

Diverse examples of the relationship between PACs and the distribution of fossil organisms are provided by

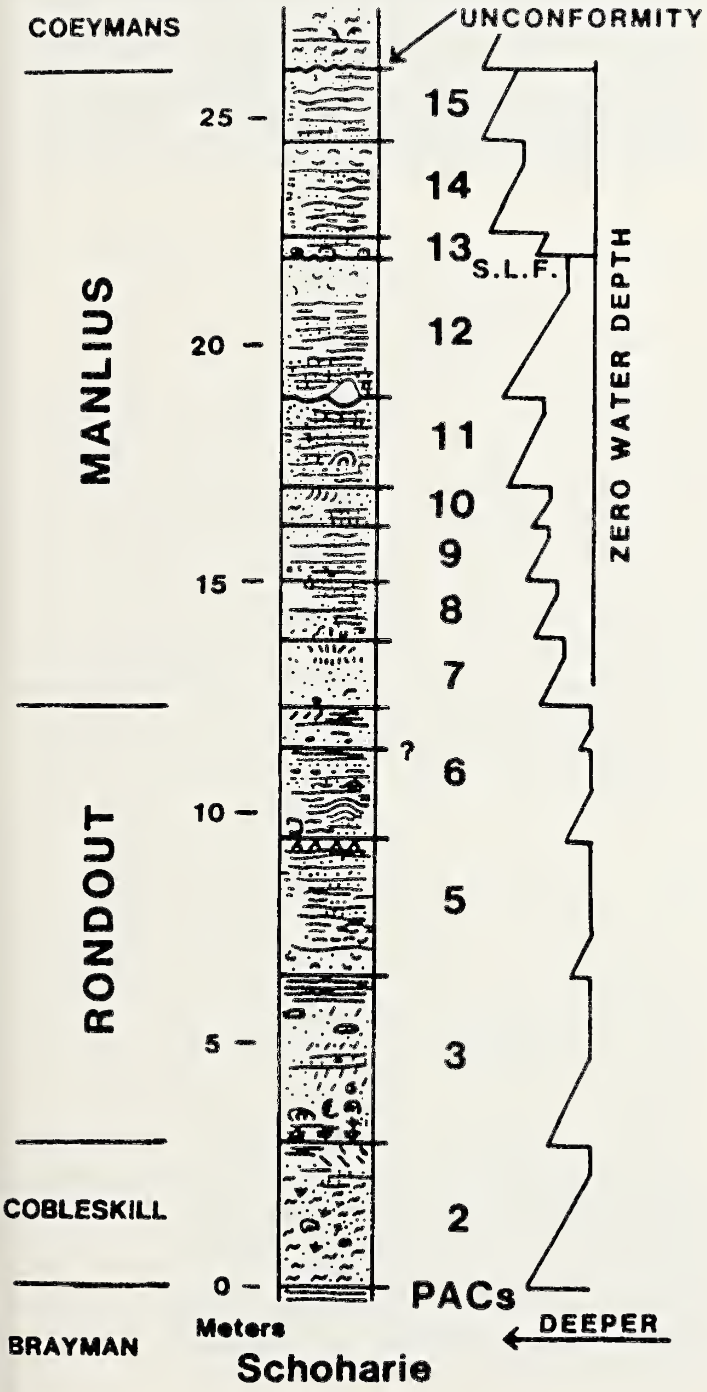
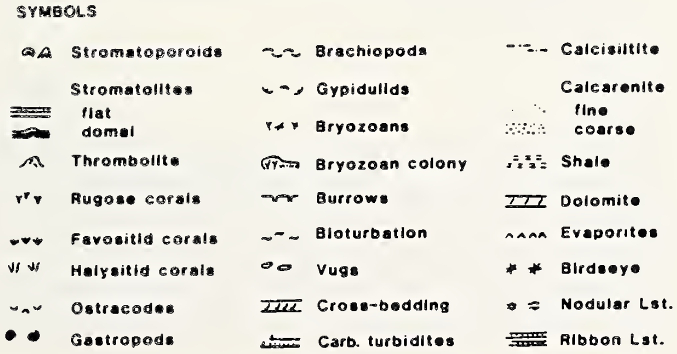


Figure 5 Columnar section of the lower Helderberg Group on Interstate 88, Schoharie, New York, with traditional stratigraphic units on the left and numbered PACs on the right. Water depth curve shows location and relative magnitude of punctuation events (horizontal segments), amounts of gradual shallowing by aggradation (diagonal segments) and proportion of each PAC attributed to gradual subsidence (vertical segments). Sea-level falls (S.L.F.) are recognized at the tops of PACs 12 and 15.



the Schoharie section (Figure5). PACs 2, 3 and 11 in the Cobleskill-Rondout-Manlius interval demonstrate upward decreases in diversity. Colonization of hardgrounds or non-depositional surfaces at PAC boundaries is well illustrated by the occurrence of *in situ* stromatoporoids at the base of PACs 2 and 13, bryozoan-mounds at the base of PAC 7 and thrombolitic algal mounds at the base of PAC 12. An increasingly restricted tidal-flat sequence with ostracodes through domal stromatolites to flat stromatolites is expressed in PAC 6.

Finally, distinctive faunal associations are restricted to small groups of PACs at several levels in the stratigraphic sequence at Schoharie (Figures 5 and 6): an association of tabulate and rugosan corals with stromatoporoids in PACs 2 and 3; a strophomenid brachiopod association in PACs 14 and 15; a pentamerid, atrypid and crinoid association in the lower 13 meters of the Coeymans Formation; a cystoid bryozoan association in 4 PACs in the upper Coeymans; and finally a return to a pentamerid association in the upper Coeymans PAC, just below punctuation event B.

TRISTATES GROUP (DWF, EL)

Oriskany Sandstone

The Oriskany Sandstone in the Cherry Valley region is actually a medium-grey weathering, light bluish-grey limestone with scattered, large, spherical quartz grains. To the west of Cherry Valley, the Oriskany is a relatively pure quartz arenite with a patchy distribution. Similarly, the Oriskany is a quartz arenite to the east of Cherry Valley along the Helderberg Mountain front at Thacher State Park. Further south in the Hudson River Valley the stratigraphic position of the Oriskany is occupied by siliceous cherty limestones (Glenerie) or a quartz pebble conglomerate (Connelly). The near shore, high energy environment of the Oriskany was dominated by large brachiopods (*Acrospirifer*, *Costispirifer*, *Hipparionyx*, and *Rensselaeria*) that compose Boucot and Johnson's (1967) "Big Shell Community." The Oriskany is disconformable with older units in central and eastern New York State and the quartz sand represents a remanie deposit.

Esopus Formation

The Esopus Formation is a very peculiar, geographically restricted unit in eastern New York State. The unit reflects an abrupt deepening and the appearance of dark greenish-grey to black mudstones with a sparse, benthic shelly fauna including small brachiopods and snails. The main fossils are burrows (*Planolites* and *Zoophycus*) in this presumably dysaerobic environment. The tectonic (or eustatic?) significance of the Esopus Shale is problematical. The mechanism(s) accounting for the abrupt deepening represented by the Esopus acted during an interval significantly earlier than the local Acadian orogenic events.

Carlisle Center Formation

This unit is a readily recognizable buff weathering, light grey to tan colored, calcareous, argillaceous, fine-grained quartz arenite to silty shale. The bedding surfaces of this thin-bedded, locally wave rippled unit are covered with *Zoophycus cauda-galli* traces indicating that worms (?) have severely churned this unit. The basal contact with the underlying Esopus is abrupt and the occurrence of arthropod trace fossils that are deeply incised into the underlying Esopus (Miller and Rehmer, 1982) suggests disconformity between the two formations (see Landing and Brett, 1987).

ONONDAGA LIMESTONE (RHL)

Stratigraphic Overview

The Onondaga Formation is a 21-50+ m unit of Devonian limestones observable in a west-east outcrop belt extending from Buffalo to the Helderbergs and southward, in the Hudson River Valley, to the approximate latitude of Kingston, New York. In eastern New York the base of the formation is lithologically gradational with Lower Devonian calcareous mudstones and "grits" of the Schoharie Formation. In this area, the lowermost Onondaga is marked by the regionally continuous occurrence of glauconite sand and phosphorite pebbles, indicating a minor nondepositional disconformity. West of Richfield Springs (13 miles west of Stop 1) the Onondaga rests on a slightly undulatory surface eroded into Lower Devonian and Silurian units. At many exposures throughout the area this disconformity is marked by one or more beds of quartz sand recycled from the Oriskany Sandstone (Lindholm, 1967). Throughout New York, the Onondaga is overlain by shales of the Middle Devonian Marcellus Formation. This contact is gradational in central New York, the approximate position of the Appalachian Basin axis, and abrupt in the western and eastern areas of the state.

The Onondaga Formation is divided into five members, four designated in the formation's central New York type area by Oliver (1954, 1956a) and one, the Clarence, recognized in and restricted to western New York by Ozol (1963). Thicknesses of the members at selected localities across the state are provided in Table 1 and their chronostratigraphic relations are shown in Figure 7. Each member's general lithologic and paleontologic characteristics are described below.

Edgecliff Member

The Edgecliff typically consists of thick- to massive-bedded, light-grey, coarse-grained grainstones or packstones and is characterized by the presence of crinoid columnals 2+ cm in diameter. Referred to as the "coral-bearing limestone" (Hall, 1879, p. 140) or "coral biostrome" (Oliver, 1954, p. 635), the Edgecliff abounds with *Favosites*, *Emmonsia*, *Heliophyllum*, *Siphonophrentis*, and *Acinophyllum*. Coral reefs are known from more than thirty outcrop localities, as well as several in the subsurface of southern New York and adjacent Pennsylvania. Reef corals include those listed above plus *Cylindrophyllum*, *Cyathocylindrium*, *Cystiphyllum*, *Cladopora*, *Pleurodictyum*, and *Thamnopora*. Additional benthic taxa known from this unit are overshadowed by the corals' dominance. However, it should be noted that the Edgecliff contains the oldest specimens of the planktonic microfossil *Styliolina fissurella* known in North America (Lindemann and Yochelson, 1984).

Clarence Member

This unit is restricted to western New York. Anastomosing masses of chert volumetrically dominate the Clarence, restricting limestone to isolated patches. The original lime sediment, which appears to have been micrite or very fine calcisiltite, has been neomorphically altered to the extent that most of whatever fossils were originally present were obliterated. Occasional fenestrate bryozoans and the ichnogenus *Chrondrites* dominate the fauna observable in the field.

Nedrow Member

In central New York, the Nedrow typically includes laminated to thin-bedded, medium dark to dark-grey,

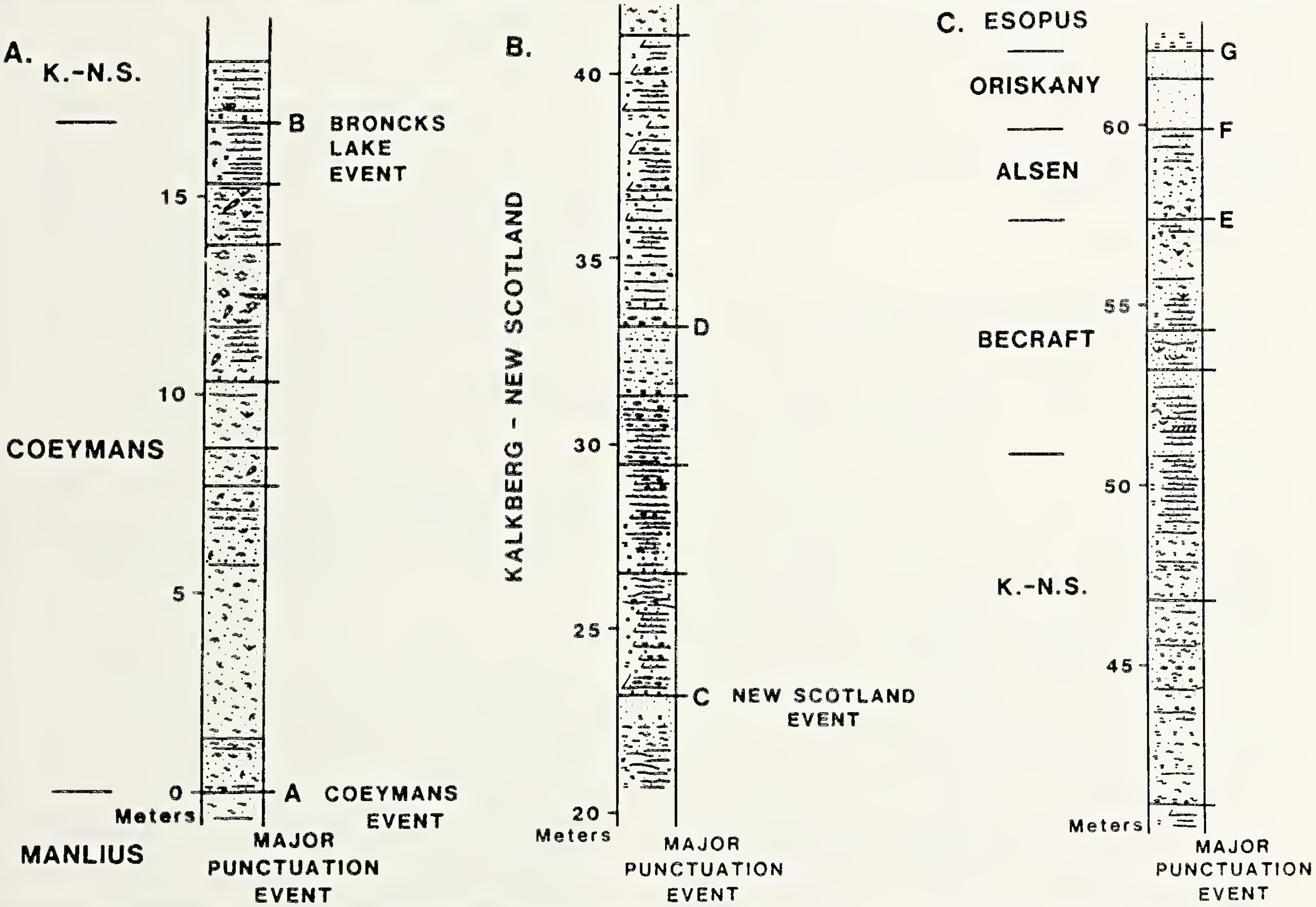


Figure 6 Columnar section of the middle and upper Helderberg Group on Interstate 88, Schoharie, New York, with traditional stratigraphic units on the left and preliminary PAC boundaries denoted by heavy horizontal lines which break the right margin of the section. Major punctuation events correlated to sections in the Hudson Valley are lettered. A. Coeymans Formation (note cystoid fauna between 7-15 meters); B. lower Kalkberg-New Scotland Formations (note shallowing PAC sequence between 23-33 meters); C. upper Kalkberg-New Scotland to Oriskany Formations.

argillaceous, mudstones and wackestones. This lithology extends eastward to Cherry Valley (Stop 1) where the unit consists of alternating beds of laminated argillaceous wackestones and medium-bedded, relatively clean wackestones and packstones. East of Cherry Valley the Nedrow is lithologically indistinguishable from the underlying Edgecliff Member and the overlying Moorehouse Member above.

Oliver (1956) correlated the coarse-grained beds of eastern New York with the type Nedrow based on the occurrence of several large platyceratid gastropod species which he considered to be characteristic of the member. In addition to the platyceratids, the small rugose coral *Amplexiphyllum hamiltoniae* and a diminutive turbinate form of *Heliophyllum halli* are common Nedrow fossils as are the brachiopods *Atrypa reticularis* and *Leptaena rhomboidalis*. Due to their high clay content, Nedrow hand specimens are readily disagregated and yield an abundance of calcareous microfossils such as *Styliolina fissurella* and diverse ostracods including *Amphizona*, *Chironspectrum*, and *Reticestus*?. For biostratigraphic purposes it is of interest that the upper Nedrow at Cherry Valley (Stop 1) contains two conodont subspecies *Polygnathus costatus costatus* and *P. costatus patulus* (Klapper, 1981).

Moorehouse Member

The central New York type Moorehouse is a sequence of medium- to thick-bedded, medium-grey, fine-grained, wackestones and grainstones with numerous shaly partings. Nodules and thin beds of dark-grey to black chert are common, particularly in the upper half of the member. As previously noted, the Moorehouse of eastern New York is lithologically similar to the Edgecliff Member. This also is true in western New York. The shift in Moorehouse lithofacies east and west of the member's type area is reflected by the fauna. In central New York the fauna is dominated by brachiopods such as *Chonetes*, *Athyris*, *Schuchertella*, and *Protoleptostrophia* along with the trilobites *Odontocephalus* and *Phacops*. The eastern fauna is dominated by diverse bryozoans, most notably *Fistulipora*, along with numerous platyceratid gastropods and corals. The Cherry Valley area appears to occupy a transitional position between the central and eastern facies. East of here the Moorehouse is the uppermost Onondaga member and is directly overlain by the Marcellus Shale.

Seneca Member

The Seneca is typically a very thin- to medium-bedded, medium dark grey, fine-grained wackestone which grades upward into the Marcellus Shale. The Seneca's base is often lithologically similar to the upper Moorehouse on which it rests, and is delineated from the Moorehouse by the Tioga Bentonite horizon (Oliver, 1954). The easternmost outcrop of the Tioga within the Onondaga Formation and of the Seneca Member itself is at Cherry Valley (Stop 2). Here the member is predomi-

	LOCATIONS	Buffalo	Leroy	Syracuse	Cherry Valley	Cobleskill	Helderbergs	Catskill-Leeds
MEMBERS	Seneca	12.3m + 40' +	9.2m 30'	7.8m 25.5'	2.1m 7'	- -	- -	- -
	Moorehouse	17m 55'	17m 55'	7m 23'	22.9m 75'	21.3m 70'	21.3m 70'	11.3m + 37' +
	Nedro	uncertain	uncertain	4.3m 14'	3.7m 12'	4m 13'	4.6m 15'	13.1m 43'
	Clarence	13.8m 45'	13.8m 45'	- -	- -	- -	- -	- -
	Edgecliff	3.1m 10'	3.1m 10'	6.1m 20'	7m 23'	9.1m 30'	9.1m 30'	10.7m 35'
	Totals	45.7m + 150' +	42.7m 140'	25m 82'	35.7m 117'	34.4m 113'	35m 115'	35m 115'

Table 1 Average thickness of the Onondaga Limestone and its members across New York State.

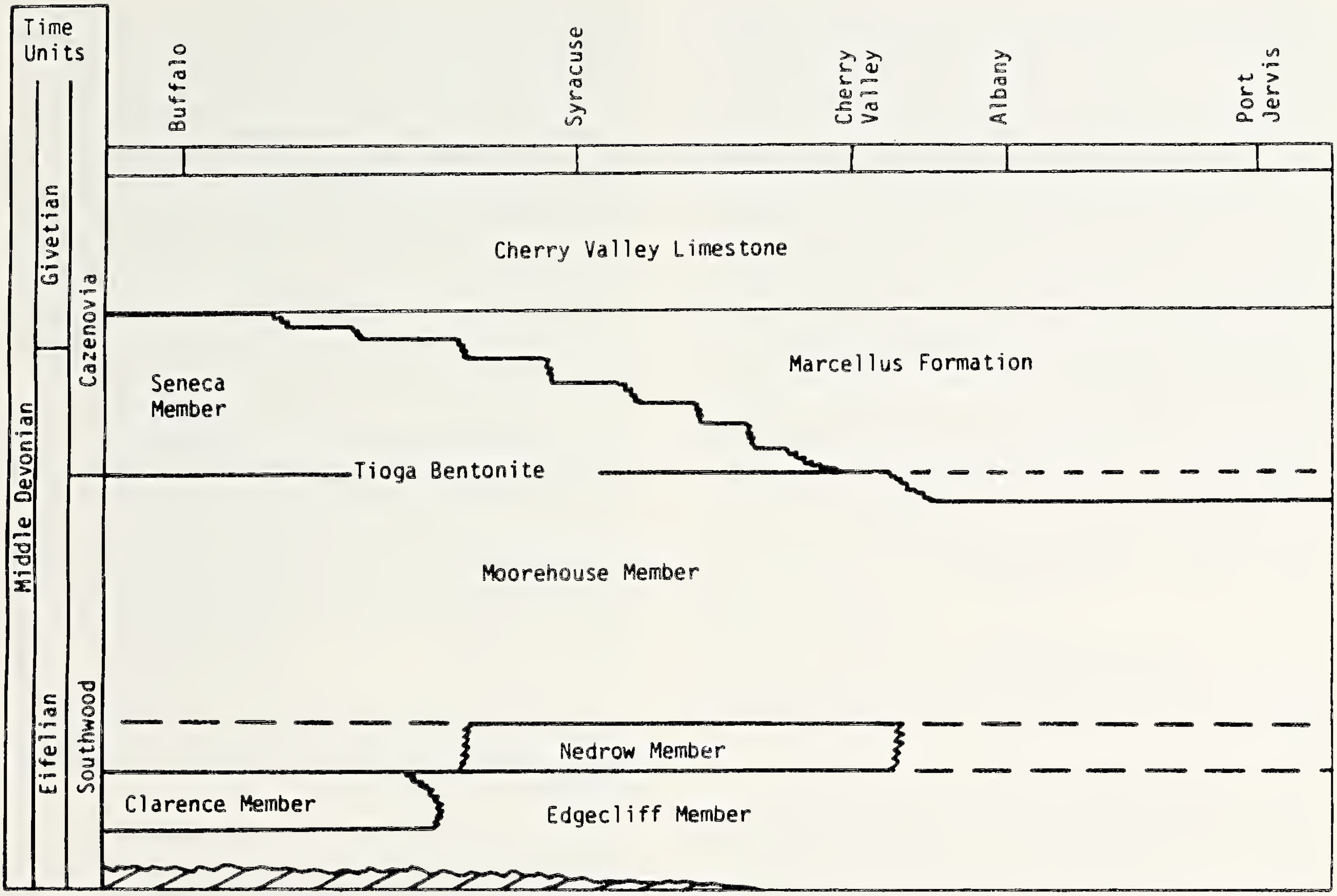


Figure 7 **Chronostratigraphic correlation of the Onondaga Formation throughout New York State. Horizontal dimension not to scale. Adapted from Oliver and others (1969) and Rickard (1975).**

nately a coarse crinoidal sand (packstones and grainstones); the fauna is dominated by fenestrate bryozoans and *Atrypa reticularis*, and the unit is abruptly overlain by the Marcellus Shale. Additional detail is provided in the trip log description of Stop 2.

Correlation of the Onondaga Limestone

The biostratigraphic basis for correlation of the Onondaga Formation, particularly the Edgecliff Member, to the standard biozones and stages of Europe reads like a "who-done-it?" with the last few pages missing. Brachiopod and coral faunas have long served to place the formation at the base of the Middle Devonian Series (Rickard, 1975). Dutro (1981) reports that the Edgecliff Member coincides with the base of the *Frimbrispirifer divaricatus* Subzone of the *Amphigenia* Assemblage Zone which marks the base of the Southwoodian (=Upper Onesquethawan) Stage. Similarly, Oliver and Sorauf (1981) state that the Edgecliff base coincides with the base of the *Acinophyllum segreatum* Assemblage Zone and the bottom of the Southwoodian Stage. High in the formation, the Seneca Member is within the *Paraspirifer acuminatus* Assemblage Zone as well as an unnamed coral assemblage zone (8 of Oliver and Sorauf, 1981), both of which place the Seneca in the Cazenovian Stage. These fossils firmly establish the Onondaga Edgecliff Member as the lowermost Middle Devonian unit in New York State relative to the North American stages. However, Onondaga corals and brachiopods are geographically restricted to North America, a condition which precludes direct correlation with the Eifelian Stage of Europe. Cephalopods do little to facilitate this correlation. *Foordites* cf. *buttsi* from the Nedrow Member (Oliver, 1956b; House, 1962) suggests an Eifelian age. However, House (1981) notes that *Foordites* is a long-ranging genus, and that European zonal taxa are not known from the Onondaga. Furthermore, *Foordites* has not been reported from the Edgecliff and cannot lend its support to interpretation of an Eifelian age for the lowermost Onondaga member.

The International Union of Geological Sciences recently ratified the decision of the Subcommission on Devonian Stratigraphy to establish the base of the Middle Devonian Series and the Eifelian Stage at the first occurrence of the conodont *Polygnathus costatus partitus* (Ziegler and Klapper, 1985). The subspecies *partitus* is the second in a lineage of three which are sequentially related as shown in Figure 8. Thus, the bottom of the *patulus* Zone is high in the Emsian Stage and the bottom of the *costatus* Zone is well within the Eifelian. Klapper (1981) reports that the upper Nedrow beds at Cherry Valley yield both *P. c. costatus* and *P. c. patulus*, placing the member's top well within the *partitus* Zone (Figure 8). Noting this along with the fact that *P. c. partitus* is unknown from the Onondaga, Ziegler and Klapper (1985) suggest, with question marks, that the Edgecliff Member is within the *patulus* Zone and correlative to the Emsian Stage of the Lower Devonian Series. At the very least, this obfuscates the Lower-Middle Devonian boundary in New York State and speaks for a "handle with care" approach in transatlantic correlation of the North American stages which abut that boundary. To date the chronostratigraphic placement of the lowermost Onondaga member remains uncertain.

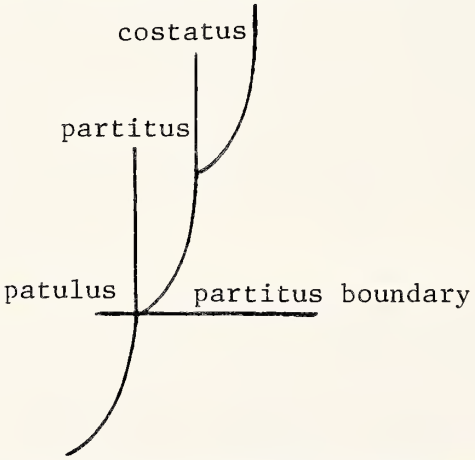


Figure 8 **Vertical relationship of the *Polygnathus costatus* subspecies (from Ziegler and Klapper, 1985).**

HAMILTON GROUP STRATIGRAPHY (DWF, EL)

The Hamilton Group is a siliciclastic-dominated sequence that reflects the influx of sediments derived from the rising Acadian orogen to the east. Only the lowest (Marcellus Formation and local coarse-grained equivalents) formation of the four formations of the Hamilton Group (see Cooper, 1930) will be investigated on this excursion.

The Marcellus Formation is primarily black and grey shales and siltstones with rare thin black limestones in the excursion area. In general, both benthic and planktic fossils are rare in the dysaerobic to anoxic, deeper water facies of the Marcellus.

The lower portion of the Marcellus is divisible into three members based on the abrupt appearance of the Cherry Valley Limestone and related carbonates within a black shale sequence (Stop 3). The light-grey to tan weathering, black fossil wacke- to packstone of the Cherry Valley is the youngest limestone in eastern New York State. The unit has been called the "*Agoniatites* Limestone" in the older literature because of the prominent cephalopod component of the fauna. The Union Springs Shale (Cooper, 1930) under the Cherry Valley is a fissile black shale with calcareous nodules and very limited and sparse benthic fauna in local, thin argillaceous limestones. The Chittenango Shale (Cooper, 1930) overlies the Cherry Valley Limestone and is similar to the Union Springs but has exceedingly rare benthic fossils. Simple, small conical calcareous tubes representing problematical organisms such as tentaculitids and styliolinids are more characteristic of these shales.

Rapid accumulation of Acadian orogen-derived siliciclastics allowed progradation of nearshore environments into eastern New York while more open marine conditions persisted through the Hamilton Group in central and western New York State. These marginal marine deposits are the Mount Marion Formation (Stop 8) in the excursion area and represent equivalents of the middle and upper portions of the Marcellus Formation (see Rickard, 1975).

Faunas, Stratigraphy and Depositional Environments of the Cherry Valley Limestone and Associated Carbonates (CEB, GK)

The Union Springs-Cherry Valley sequence is presently considered to be of latest Eifelian age based on the occurrence of the conodont *Tortodus kockelianus kockelianus* in the basal Cherry Valley Limestone in central New York (see Klapper, 1981). The so-called "*Werneroceras*" bed in the upper Union Springs shale has also yielded goniatites diagnostic of the late Eifelian or earliest Givetian (House, 1981).

The basal contact of the Union Springs is not exposed at Stop 3 (Figure 9) but nearby localities reveal that the black shale sharply overlies the uppermost Onondaga with probable disconformity. The lowest portion of this roadcut exposes sparsely fossiliferous, sooty, black, fissile Union Springs shale which is locally about 11-13 m thick. Two 20 cm-thick zones of "crumpled" slicken-sided and cleaved shale occur in the upper Union Springs. These intervals, which are under and overlain by undisturbed shales, have been interpreted as shear zones associated with a major decollement in the Marcellus that was produced during late phases of the Acadian or the Alleghanian orogeny (Bosworth, 1984a, b). A small scale southeast-over-northwest ramp structure in the Cherry Valley Limestone at this locality may reflect the same thrusting event.

The uppermost part of the Union Springs Member overlying the shear zone contains a sequence of thin concretionary limestones, some of which contain fossils. Recent detailed collection of this section by one of us (GK)

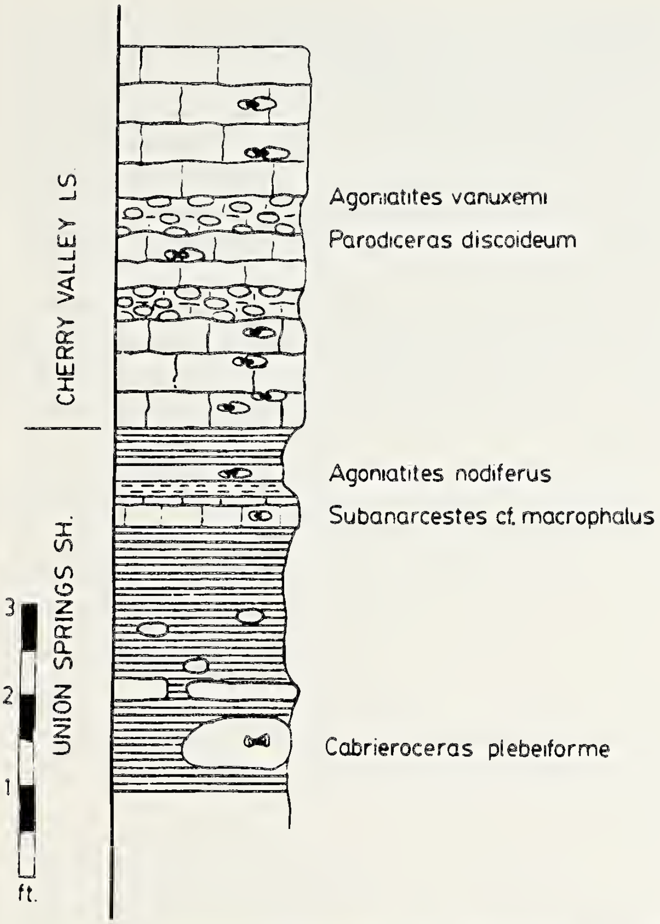


Figure 9 **Goniatite sequence and general lithosequence of the lower Marcellus Formation at Chestnut Street locality (Stop 3).**

has revealed a condensed sequence of three goniatite horizons within this meter-thick interval. These distinct goniatite bearing horizons are regionally mappable and were partly recognized by earlier workers (e.g. Rickard, 1952), but some confusion has existed in the terminology of the beds. The lowest goniatite bearing units are large, septarian carbonate concretions that occur one meter below the base of the Cherry Valley Limestone. These nodules yield specimens of *Cabrieroceras plebeiforme* (formerly *Werneroceras plebeiforme*). Smaller concretions in the overlying 0.7 m (2.5 feet) of shale at this locality appear to be barren. The latter goniatite was formerly reported as occurring in a thin-fossiliferous limestone band about 0.3 m below the Cherry Valley limestone which has long been termed the *Werneroceras* bed (Flower, 1943; Rickard, 1952; House, 1981; Klapper, 1981). However, this designation is erroneous and the bed should be renamed; we employ the term "Proetid bed." The confusion results because the Proetid bed has an erosional base and bears prefossiliferous specimens of *Cabrieroceras* ("*Werneroceras*") reworked from the underlying shales of Cox Ravine, the Cherry Valley type section. In actuality, the Proetid bed does not normally contain *Cabrieroceras* and, locally, at Thompsons Lake, the *Cabrieroceras* zone lies as much as 6 m (20 feet) below the Proetid bed.

The Proetid bed itself is a double layer of light grey, fossiliferous limestone which is separated from the base of the Cherry Valley limestone by 0.3-0.5 m of shale in the type area but merges with the Cherry Valley in central New York. The bed yields abundant specimens of small, unidentified rugose corals and disarticulated cephala and pygidia of *Proetus*? *haldemani*, as well as atrypids, and other brachiopods (see Rickard, 1952). Although the Proetid bed does not contain *Cabrieroceras*, except as reworked specimens, it does have two other species of goniatites which occur separately in the two discrete layers of the bed. The thicker (10 cm) lower unit contains reworked specimens of *Subanarcestes* cf. *S. macrophalus* which appears to be restricted to this thin layer while the thinner (5 cm) upper layer as well as overlying shale contains *Agoniatites nodiferus*. To the best of our knowledge these two goniatites never actually occur together.

The Proetid bed is traceable, at least, from the Seneca Lake area in the west eastward to the Berne Quadrangle where it consists of two layers totalling 40 cm in thickness and displays a series of graded crinoidal debris layers.

The highest dark shales of the Union Springs contain flattened specimens of *Agoniatites nodiferus* in a thin, slightly harder (silty) layer 15 cm below the base of the Cherry Valley Limestone.

The Cherry Valley Member itself, formerly termed the *Agoniatites* Limestone by Clarke (1901), is about 1.2 m thick and consists of three subunits: lower and upper massive, dark grey (orange-buff weathering) styliolinid packstone layers, each about 0.45 m thick, and a middle interval, also about 0.5 m thick, which is more argillaceous and contains nodular styliolinid packstone. The Cherry Valley Limestone, as a whole, is characterized by an unusual, low diversity fauna dominated by *Styliolina*, diminuitive brachiopods, gastropods, the nautiloid *Striacoceras* and the goniatites *Agoniatites vanuxeni* and *Paradiceras discoideum* (Flower, 1936). The lowest ledge contains abundant brachiopods. The upper bed contains abundant goniatites, brachiopods and gastropods and a layer 15 cm below the top is particularly rich in cephalopods. Thickets of auloporid corals occur at the base and top of the middle, nodular unit (Cottrell, 1972). A few small unidentified rugose corals occur in the upper ledge. Crinoid debris is scattered throughout much of the limestone.

The highest units in this roadcut (Stop 3) are black, laminated shales of the Chittenango Member. These shales contain a few thin concretionary limestones near the base and rare fossils consisting of styliolinids and a few *Leiorhynchus* brachiopods.

The Marcellus black shales record the first influx of siliciclastic muds from Acadian source terranes. These sediments accumulated under relatively deep water, anoxic to dysaerobic basinal conditions. These conditions are indicated by lamination, high organic content, and low diversity pelagic-dominated faunas. Rarity of microboring in shells from these facies (Vogel *et al.*, in prep.) indicates a dysphotic to subphotic depositional site. The Union Springs shale is highly calcareous. This indicates some continued influx of carbonates from marginal production sites; in central New York, this unit appears to be gradational with the underlying dark, bituminous Seneca Member of the Onondaga Limestone.

The upper Onondaga-Union Springs interval represents a transgressive sequence which is probably, in part, related to a late Eifelian eustatic sea level rise (House, 1983; Johnson *et al.*, 1985). In the northern Appalachian Basin deepening also may have been enhanced by tectonic subsidence of the foreland basin. As noted below, there appears to be evidence for tectonic instability in eastern New York at this time.

Beds of small carbonate concretions and nodules within the upper Union Springs shale may represent minor episodes of slower deposition and/or carbonate enrichment associated with a general shallowing. The appearance of sparse benthic fossils (*Leiorhynchus*, nuculid bivalves, gastropods) and *Chondrites* burrows in these upper beds demonstrates a change from anaerobic to dysaerobic or minimally aerobic (restricted) bottom conditions. This trend appears to culminate in the "Proetid" bed which contains a relatively well developed benthic fauna of small rugosans, brachiopods, crinoids and mollusks. In eastern outcrops in the Berne Quadrangle, this unit also contains upward-fining layers of crinoidal debris that were probably produced by storm disturbance of the seafloor. Present evidence further suggests that the bed may form the cap of the upward regressive Stony Hollow Sandstone further south in the Hudson Valley. The Cherry Valley Limestone appears to represent a distinctive unit which is separated from the top of the main Stony Hollow by about 3 m of dark, softer shales at Onesquethaw Creek, the northwesternmost outcrop of the Stony Hollow (Rickard, 1952). This stratigraphic evidence suggests that the proetid bed is actually the signal of the strongest regressive event, a shallowing accompanied by progradation of coarser clastics (Stony Hollow silts and sands) in the Hudson Valley and the appearance of an aerobic shelly fauna over much of the New York outcrop belt. This pattern is consistent with that observed for higher Hamilton shelly carbonate units (Brett and Baird, 1985); the upward-coarsening trend, better bottom oxygenation, and introduction of shallow water shelly fauna probably represent responses to the same basinwide sea level drop.

In contrast, the Cherry Valley Limestone proper does not follow the usual pattern. It is dominantly a styliolinid and cephalopod (pelagic) packstone. The low diversity benthic fauna of auloporid corals, *Paleozygopleura* gastropods, and small ambocoeliid and leiorhynchid brachiopods, is virtually identical to that found in surrounding dark shales. It apparently represents a tolerant fauna adapted to dysaerobic, deeper water conditions.

This may have resulted from rapid transgression of shallow seas and consequent sediment starvation in the basin. The shaley middle division of the Cherry Valley seems to record a minor pulse of increased siliciclastic deposition.

Deposition of Cherry Valley carbonates was apparently episodic; long spans of very slow accumulation of pelagic sediment appear to be recorded in beds of truncated "half-goniatites" similar to those described by Tanabe *et al.*, 1984. Dissolution of aragonitic shells apparently took place on the seafloor and preferentially destroyed exposed upper portions of goniatites. On the other hand, some layers of goniatites and thickets of auloporid corals are buried *in situ*, possibly when styliolinid ooze was resuspended and redeposited rapidly by very severe storms.

One of the most intriguing features of the Cherry Valley is the occurrence of layers of well preserved goniatites and nautiloids. One of these layers, occurring about 0.5 m below the top of the member at Cherry Valley, appears to be traceable westward nearly to Seneca Lake, a distance of about 240 km. This bed is estimated to contain several billion individuals of *Agoniatites*. Nautiloids in this horizon display preferred orientations suggestive of basinward flowing currents. We suggest that the horizon records a mass mortality of cephalopods and other organisms which occurred during a particularly severe storm. Following death of the cephalopods, shells evidently settled to the seafloor and were oriented and partially buried rapidly by waning storm currents. Some cephalopod shells evidently were exposed on the sea floor for some time before rapid burial. This is suggested by specimens surrounded by clusters of intact *Leiorhynchus* brachiopods that evidently were attached to the phragmocones. The bed may represent a very precise time marker. A similar explanation may apply to thin, widespread, goniatite horizons in the upper Union Springs Member (such as the *Cabrieroceras* (= *Werneroceras*) concretionary horizon and the *Subanarcestes* bed).

An important consideration is the significance of the abrupt introduction and disappearance of a succession of goniatite beds – *Cabrieroceras, Subanarcestes, Agoniatites nodiferus, A. vanuxemi.* This rapid turnover contrasts with the long persistence of tornoceratid goniatites throughout much of the Hamilton Group. Kloc (1986) has recorded the pulse-like occurrence of *Agoniatites* through the Hamilton. He notes the association of these horizons with evidence for major transgressions, and also notes an apparent absence of juvenile growth stages. This pattern seems to indicate that these goniatites (in contrast to the persistent tornoceratids) were ephemeral immigrants into the Appalachian Basin that were unable to establish viable, reproducing populations. During times of high sea level these goniatites may have invaded the Appalachian Basin from other provinces. However, they also experienced mass mortalities leading to very narrow, widespread horizons. The succession of four goniatite faunas in the Union Springs-Cherry Valley interval may represent a time of instability during which multiple invasions of goniatites took place in the northern Appalachian Basin. Each invasion was apparently followed by rapid, local exterminations. At present, it is unknown what region may have served as a source area for these immigrations.

A final feature of note displayed by the Union Springs-Cherry Valley sequence is the series of submarine unconformities. Erosion surfaces are associated with the base of the Proetid bed (which locally truncates the underlying *Cabrieroceras* beds) and the base of the Cherry Valley. These surfaces appear to record removal of seafloor muds by currents during times of minimal sedimentation.

Westward from the Chenango Valley area, the Cherry Valley comes to be juxtaposed on the upper (hardground) surface of the Proetid bed; the amalgamation of these beds has confused stratigraphic relationships.

ACKNOWLEDGEMENTS

Portions of D.W. Fisher's comments were modified from Fisher (1979).

REFERENCES CITED

Anderson, E.J. 1972. Sedimentary structure assemblages in transgressive and regressive calcarenites. 24th Int. Geol. Cong. Section 6, p.369-378.

___________ Goodwin, P.W. and Sobieski, T.H. 1984. Episodic accumulation and the origin of formation boundaries in the Helderberg Group of New York State. Geol. 12:120-123.

Bosworth, W. 1984a. Foreland deformation in the Appalachian Plateau, central New York: the role of small scale detachment structures in regional overthrusting. J. Struct. Geol. 6:38-43.

___________ 1984b. New evidence for the extent of overthrusting in the Appalachian Plateau. Northeast. Geol. 6:38-43.

Boucot, A.J. and Johnson, J.G. 1967. Paleogeography and correlation of Appalachian Province Lower Devonian sedimentary rocks. Tulsa Geol. Soc. Digest 3, 53 p.

Brett, C.E. and Baird, G.C. 1985. Carbonate-shale cycles in the Middle Devonian of New York State: an evaluation of models for the origin of limestones in terrigenous shelf sequences. Geol. 13:324-327.

Brown, L.L., Kelly, W.M. and Landing, E. 1984. Magnetic results from carbonate rocks from central New York: Possible remagnetization. Geol. Soc. Amer. Abstracts with Prog. 16:4.

Chadwick, G.H. 1908. Revision of the "New York Series". Science, n.s., 28:346-348.

Cisne, J. and Rabe, B. 1978. Coenocorrelation: Gradient analysis of fossil communities and its applications to stratigraphy. Lethaia 11:341-364.

Clarke, J.M. 1901. Marcellus limestones of central and western New York and their fauna. New York State Mus. Bull. 49:115-138.

Cooper, G.A. 1930. Stratigraphy of the Hamilton Group of New York, Part 1. Amer. J. Sci. 19:116-134.

___________ 1934. Stratigraphy of the Hamilton Group of eastern New York, Pt. 2. Amer. J. Sci. 27:1-12.

Cottrell, J. 1972. Paleoecology of a black limestone, Cherry Valley Limestone, Devonian, New York State. *In* McLelland, J. (ed.), New York State Geol. Assoc., 44th Ann. Mtg., Guidebook, p. G-1-G-8.

Dutro, J.T., Jr. 1981. Devonian brachiopod stratigraphy of New York State. *In* Oliver, W.A., Jr., and Klapper, G. (eds.), Devonian Biostratigraphy of New York, Part 1. International Union of Geological Sciences, Subcommission on Devonian Stratigraphy, p. 67-82.

Fisher, D.W. 1979. Devonian stratigraphy and paleoecology in the Cherry Valley, New York region. *In* Friedman, G.M. (ed.), New York State Geol. Assoc., 51st Ann. Mtg., Guidebook, p. 20-33.

___________ 1980. Bedrock geology of the central Mohawk Valley, New York. New York State Mus. Map and Chart Ser. 33, 44 p.

___________ and Rickard, L.V. 1953. Age of the Brayman Shale. New York State Mus. Circ. 36.

Flower, R.H. 1936. Cherry Valley cephalopods. Bull. Amer. Paleont. 22(76), 96 p.

___________ 1943. *Werneroceras* in the Devonian of New York. Bull. Amer. Paleont. 28:14-21.

Goldring, W. 1935. Geology of the Berne Quadrangle. New York State Mus. Bull. 303, 238 p.

Goodwin, P.W. and Anderson, E.J. 1985. Punctuated aggradational cycles: a general hypothesis of episodic stratigraphic accumulation. J. Geol. 93:515-533.

___________, ___________, Goodman, W.M. and Saraka, L.J. 1986. Punctuated aggradational cycles: implications for stratigraphic analysis. Paleoceanography (in review).

Hall, J. 1879. Containing descriptions of the Gastropoda, Pteropoda, and Cephalopoda of the Upper Helderberg, Hamilton, Portage and Chemung groups. Palaeontology of New York, 5, 492 p.

House, M.R. 1962. Observations on the ammonoid succession of the North American Devonian. J. Paleont. 36:247-284.

___________ 1981. Lower and Middle Devonian goniatite biostratigraphy. *In* Oliver, W.A., Jr., and Klapper, G. (eds.), Devonian Biostratigraphy of New York, Part 1. International Union of Geological Sciences, Subcommission on Devonian Stratigraphy, p. 33-37.

___________ 1983. Devonian eustatic events. Proc. Ussher Soc. 5:396-405.

___________ 1985. Correlation of mid-Paleozoic ammonoid evolutionary events with global sedimentary perturbations. Nature 313:17-22.

Johnson, J.G., Klapper, G. and Sandberg, C.A. 1985. Devonian eustatic fluctuations in Euramerica. Geol. Soc. Amer. Bull. 96:567-587.

Klapper, G. 1981. Review of New York Devonian conodont biostratigraphy. *In* Oliver, W.A., Jr., and Klapper, G. (eds.), Devonian Biostratigraphy of New York, Part 1. International Union of Geological Sciences, Subcommission on Devonian Stratigraphy, p. 57-66.

Kloc, G.J. 1986. Distribution of goniatitic ammonoids in the Middle Devonian (Givetian) Hamilton Group of New York. Geol. Soc. Amer. Abstracts with Programs 18:27.

Landing, E. 1988. Cambrian-Ordovocian boundary in North America: Revised Tremadocian correlations, unconformities and "glacioeustasy." New York State Mus. Bull. 462.

___________ and Brett, C.E. 1987. Trace fossils and regional significance of a Middle Devonian (Givetian) disconformity in southwestern Ontario. J. Paleont. 61:205-230.

Laporte, L.F. 1967. Carbonate deposition near mean sea-level and resultant facies mosaic: Manlius Formation (Lower Devonian) of New York State. Amer. Assoc. Petrol. Geol. Bull. 51:73-101.

___________ 1969. Recognition of a transgressive carbonate sequence within an epeiric sea: Helderberg Group (Lower Devonian) of New York State. *In* Friedman, G.M. (ed.), Depositional Environments in Carbonate Rocks: Soc. Econ. Paleon. and Miner. Spec. Pub. 14:98-119.

Lindemann, R.H. and Yochelson, E.L. 1984. Styliolines from the Onondaga Limestone (Middle Devonian) of New York. J. Paleont. 58:1251-1259.

Lindholm, R.C. 1967. Petrology of the Onondaga Limestone (Middle Devonian), New York. Doctoral dissertation, John Hopkins Univ., 188 p.

Miller, D.S. and Senechal, R.G. 1965. Age determinations in New York State. Trans. Amer. Geophys. Union 46:173.

Miller, M.F. and Rehmer. 1982. Using biogenic structures to interpret sharp lithologic boundaries: An example from the Lower Devonian of New York. J. Sediment. Petrol. 52:887-895.

Oliver, W.A., Jr. 1954. Stratigraphy of the Onondaga Limestone (Devonian) in central New York. Geol. Soc. Amer. Bull. 65:621-652.

___________ 1956a. Stratigraphy of the Onondaga Limestone in eastern New York. Geol. Soc. Amer. Bull. 67:1441-1474.

___________ 1956b. *Tornoceras* from the Devonian Onondaga Limestone of New York. J. Paleont. 30:402-405.

___________ 1957. Middle Devonian coral beds of central New York. Amer. J. Sci. 249:705-728.

___________, deWitt, W., Jr., Dennison, J.M., Hoskins, D.M. and Huddle, J.W. 1969. Correlation of Devonian rock units in the Appalachian Basin. U.S. Geol. Surv. Oil and Gas Inv. Chart Oc-61.

___________ and Sorauf, J. E. 1981. Rugose coral biostratigraphy of the Devonian of New York and adjacent areas. *In* Oliver, W.A., Jr., and Klapper, G. (eds.), Devonian Biostratigraphy of New York, Part 1, International Union of Geological Sciences, Subcommission on Devonian Stratigraphy, p. 97-105.

Ozol, M.A. 1963. Alkali reactivity of cherts and stratigraphy and petrology of cherts and associated limestones of the Onondaga Formation of central and western New York. Doctoral dissertation, Rensselaer Polytechnic Inst., 228 p.

Read, J.F., Grotzinger, J. P., Bova, J.A. and Koerschner, W.F. 1986. Models for generation of carbonate cycles. Geol. 14:107-110.

Rickard, L.V. 1952. The Middle Devonian Cherry Valley Limestone of eastern New York. Amer. J. Sci. 250:511-522.

___________ 1962. Late Cayugan (Upper Silurian) and Helderbergian (Lower Devonian) stratigraphy in New York. New York State Mus. and Sci. Serv. Bull. 386, 157 p.

___________ 1975. Correlation of the Silurian and Devonian rocks in New York State. New York State Mus. and Sci. Serv. Map and Chart Ser. 24.

Tanabe, K., *In* Azumi, A., Tamahama, K. and Takashi, K. 1984. Taphonomy of half and compressed ammonites from the Lower Jurassic black shales of Toyora area, west Japan. Paleogeogr. Palaeoclimatol., Palaeoecol. 47:329-346.

Ziegler, W. and Klapper, G. 1985. Stages of the Devonian System. Episodes 8:104-109.

ROAD LOG

Mileage

0.0 Depart from Cathedral Parking Lot on

	east side of New York State Museum. Turn right onto Madison Avenue (U.S. Route 20) and descend downhill toward the Hudson River. This east-facing slope was produced by the erosion of Glacial Lake Albany clays.
0.3	Cross South Pearl Street and continue east; follow road signs toward U.S. Interstate 787 and the Thomas E. Dewey Thruway (U.S. Interstate 87).
0.6	Turn right onto access ramp to U.S. 787 (south).
1.9	Turn right onto Thruway access ramp at Interchange 23.
2.4	Toll booth at Interchange 23, continue onto U.S. Interstate 87 (west).
4.3	The horizon on the south is the Helderberg escarpment which overlooks the Mohawk Lowlands.
5.1	Low, rolling and gullied topography developed on Pleistocene sand dunes. The route passes through this dune terrane for the next 10 km. The characteristic pine and oak forest of the "Pine Bush" is one of the most northern developments of this plant community. The Pine Bush is the major aquifer of the Albany region. This unique and vital habitat/resource is, of course, threatened by "development."
8.5	Pass Exit 24, to Northway, Route 87 (North).
12.5	To the west and directly in front of bus, distant view of large hill underlain by upper Middle Ordovician Schenectady Formation.
14.6	Pass Exit 24 (to Schenectady).
15.1	Begin long descent into the Mohawk River Valley.
19.7	Pass Exit 25A (to U.S. Interstate 88).
22.7	Beginning of cut on south lane of Thruway in thin bedded sandstones and siltstones of the Schenectady Formation (late Middle Ordovician). The synorogenic flysch of the Schenectady Formation represents the onlap of coarser detritus across eastern New York State by the erosion of the emergent Taconian accretionary prism. The "Schenectady Formation" is a local designation applied to Martinsburgtype turbidites. The Schenectady is more than 800 m thick.
23.0	Pass Exit 26 to Rotterdam. Note the Mohawk River to the right (north). We will remain in the Mohawk River Valley until we exit the Thruway at Canajoharie. The deep valley of the Mohawk River was incised by drainage from the ancestral Great Lakes in the interval 13,000-16,000 years before present.
25.0-25.7	Pass long roadcut in Schenectady Formation on south side of road. The bus will slow to show a low angle truncation surface in the thin-bedded turbidites in the middle portion of the roadcut. The feature demonstrates detachment and westerly movement of the sediments toward the axis of the Martinsburg trough. The western margin of this deep water embayment marginal to the Taconic orogen lay in the vicinity of Herkimer where the relatively shallow carbonate platform of the Trenton Group is replaced eastward by the Utica Shale. The slope sequence of calcareous turbidites and black shales on the easterly margin of the Trenton platform is Fisher's (1980) "Dolgeville facies".
29 1-29.5	Exit into Pattersonville Service area for brief rest stop (15 minutes). Upon departing from the bus, look back along the Thruway to the low cuts in dolostone on the south lane. We have just passed over one of the major block faults in the Mohawk River Valley. The Hoffman's fault brings the Tribes Hill Dolostone (Lower Ordovician) into contact with the Schenectady Formation. A number of similar faults with the west side upthrown will be crossed as the bus approaches Canajoharie. These south-southwesterly trending faults may represent reactivation of older (late Precambrian) lines of weakness in an interval after the later portion of the Ordovician and prior to the local Late Silurian.
33.5	Service area on south side of Thruway and view of the City of Amsterdam and Mohawk River to the north.
35.1	Pass Exit 27. Note the deep cut in the Utica Shale on the south exit road. The Utica Shale is the lateral equivalent of the Schenectady Formation flysch to the east and the carbonates of the Trenton Group to the west. The Utica is overstepped and overlain by westerly progradation of the

turbidites of the Schenectady Formation. In this roadcut, limonitic stains coat the rock surface below centimeter-thick reentrants that may mark ash beds. These have been used for internal subdivision of the monotonous shales of the Utica (see Cisne and Rabe, 1978).

39.6 Cross Schoharie Creek. This is one of the largest tributaries of the Mohawk River.

43.9 Pass Exit 28 to Fultonville and Fonda.

44.5 Note cut on New York Route 5S to the south of the Thruway. The road cut is in decimeter-thick limestones of the Trenton Group. As the bus continues west, we will be traveling on a river terrace that is cut into the Trenton Group.

45.8 Cuts along New York Route 5S to the south of the Thruway are in the Utica Shale. The gentle westerly dip of the strata has allowed us to climb through the sequence of the Trenton Group in this fault block.

46.4 Road cut on the south side of the Thruway includes 1.5 m of the Lower Ordovician Tribes Hill Formation disconformably overlain by approximately eight meters of Trenton Group limestones with syndepositional folds. The Utica Shale caps the road cut.

47.1 The first view of the dramatic scarp of the Noses Fault may be seen directly to the west.

48.6 High cliffs to the northwest mark the scarp of the Noses Fault. The cliffs are composed of Tribes Hill Formation (Lower Ordovician) and underlying Little Falls Dolostone (Upper Cambrian and lowermost Ordovician). The contact of these formations is a disconformity separating the uppermost *Cordylodus proavus* Zone from overlying dolostones with Fauna C conodonts (Brown, Kelly and Landing, 1984). This disconformity is widespread in North America and is considered to mark onlap events in the earliest Tremadocian (Landing, 1988).

50.4 Cross the Noses Fault. Dark grey outcrops in the Mohawk River to the north are Grenvillian gneisses that underlie the Little Falls Dolostone. The approximately coeval Potsdam Sandstone, which is the characteristic lowest Paleozoic unit in the Champlain Lowlands, is not present on the south-central and southwestern margin of the Adirondack Uplands.

51.9-52.5 The high cliffs on the south side of this watergap of the Mohawk River are composed of Little Falls Dolostone and overlying Tribes Hill Dolostone.

56.2 Leave Thruway at Exit 29, Canajoharie, New York.

56.5 Railroad cuts and quarry in the Little Falls Dolostone are visible directly to the south as the bus crosses bridge over the Thruway.

56.7 Pass through toll booth and turn right (west) onto New York State Route 10.

57.05 Cross Canajoharie Creek in the village of Canajoharie. A section from the lower part of the Tribes Hill Formation into the Utica Shale is completely exposed upstream from the bridge (see Fisher, 1980).

57.1 Turn south (left) onto Route 10S and continue toward Sharon Springs. As the bus climbs the hill, the route crosses the Tribes Hill Formation (low cuts on the right side of the road), passes through Trenton Group, and enters the gently rolling topography of the Utica Shale.

59.5 The horizon to the south is dominated by the rolling topography developed on the Lower and Middle Devonian carbonate sequence. The hill tops are capped by siliciclastics of the Hamilton Group.

61.6 Junction with Montgomery County Route 163 to Sprout Brook; continue south on Route 10.

63.7 Crossroads in Village of Ames, New York.

65.2 Enter Schoharie County.

66.75 Village of Sharon Springs. The large old hotel buildings are left from the years that the village was a health spa noted for its sulfurated water.

66.8-67.05 The route ascends a stream valley with a long road cut in black shales and decimeter-thick sands of the Frankfort Formation (upper Middle Ordovician). The persistent hydrogen sulfide odor that is continually evolved from the shales is celebrated by the local name for this section of road, "The Stink."

67.66 Old quarry to the west (right) of the road is in the Manlius Limestone (Lower Devo-

	nian). The underlying Upper Silurian units (Brayman Shale and Rondout Formation) do not crop out along the road.
67.7	Quarry and road cut in massively bedded Coeymans Limestone on west side of road.
67.85	Break in slope at top of hill marks the passage from the Coeymans Limestone into the less resistant Kalkberg Limestone.
67.95	Intersection with U.S. Route 20; turn right at signal light.
68.3	Drive through long roadcut in decimeter-bedded Kalkberg Limestone with stringers of black chert. The upper part of the cut becomes increasingly argillaceous.
68.6	The view to the southeast (left) is dominated by the high rounded hills that are characteristic of the Hamilton Group.
69.1	Enter Village of Leesville, New York.
69.6-69.75	Leave the Village of Leesville and pass through long cuts in cherty, argillaceous Kalkberg Limestone.
70.2	Enter Otsego County. For those who recollect any of the writings of James Fenimore Cooper, this is the general region of his "Leatherstocking Tales."
70.5	Two large dead elms to the north (right) mark a large sinkhole that is developed in the Lower Devonian.
71.2-71.4	Route climbs the low escarpment formed on the Onondaga Limestone. The small quarry just to the north (right) of the road is in the Moorehouse Member of the Onondaga Limestone.
71.6	The view to the north includes the Mohawk Valley and the Adirondack Mountains on the horizon.
72.1	The outcrop on the left (south) side of Route 20 is STOP 2 of the field trip.
72.65	Pass low cuts on the Onondaga Limestone; the upper part of the Moorehouse Member is on the right (north) and the lower part of the Seneca Member is on the south side of Route 20.
73.1	As above, cuts in the Moorehouse and Seneca members on north and south sides of road, respectively.
73.4	Pass by parking area and overlook on north (right) side of road.
73.65-73.85	Begin descent into the Cherry Valley. Exposures of the Moorehouse Member lie on both sides of the road. These are succeeded further west by yellowish-weathering exposures of the argillaceous Nedrow Member and massively bedded units of the Edgecliff Member at the base of the Onondaga Limestone.
74.0	The high roadcut on the south (left) side of Route 20 is capped by the Edgecliff Member of the Onondaga Limestone. The yellowish-weathering siltstones of the Carlisle Center Formation form the lower part of the cut. The contact of these two formations will be examined at STOP 1.
74.1	The descent to the crossroads in Cherry Valley passes a cut in the black Esopus Shale that shows the basal contact with the thin, underlying Oriskany Sandstone. The roadcut continues into the Kalkberg Limestone near the crossroad. The Becraft and New Scotland formations of the Helderberg Group are absent in this cut.
74.45	Cross intersection with New York State 166 in the Cherry Valley; continue west on Route 20 up the hill.
74.9	Park at base of long roadcut in uppermost Carlisle Springs Formation and overlying Onondaga Limestone.
STOP 1	Sub-Onondaga disconformity (RHL) (30 minutes).

Pull off the highway onto the north (right) shoulder adjacent to the lowest rock exposure on the valley's west side. The base of this outcrop is the Carlisle Center Formation which is characterized by the ichnofossil *Zoophycos (Taonurus) caudagalli*. Except for *Zoophycos* and a few other ichnofossils the Carlisle Center is unfossiliferous. In terms of lithology, the unit is approximately 50% clay with subequal quantities of quartz sand/silt and calcite. Lacking in shelly fauna and primary sedimentary structures, the depositional environment of the Carlisle Center remains uncertain.

The lowermost beds of the Onondaga Formation's Edgecliff Member are found here in a minor reentrant beneath the cliff-forming beds of the Edgecliff proper. These beds are lithologically gradational with the Carlisle Center and are rich in glauconite sand and phosphorite pebbles. Above these the Edgecliff is a sequence of fine-grained beds overlain by the massive, coarse-grained, coral biostrome typical of the unit. The upper Edgecliff contains nodules of light grey chert.

Above the Edgecliff the Nedrow Member consists of several cycles of argillaceous limestone grading upward into cleaner fine-grained wackestones. The Nedrow/Moorehouse contact is marked by the lowermost limestone bed containing dark grey chert nodules. Thin- to medium-bedded wackestones and grainstones with thin beds or nodules of dark grey to black chert are characteristic of the Moorehouse in this area. Fossils are best seen on bedding surfaces exposed in the cut.

At end of stop, turn back (east) on Route 20.

76.95 Pass by parking area and overlook on north (right) side of Route 20.

77.9 Park on south shoulder of east-bound lane on Route 20 at road cut.

STOP 2 Tioga "Bentonite": Contact of the Moorehouse and Seneca Members of the Onondaga Limestone (RHL) (20 minutes).

The 2 m exposure of massive limestone seen here on the south (right) side of Route 20 is the easternmost outcrop of the Seneca Member. The Tioga bentonite occurs in the reentrant at the exposure's base and the uppermost Moorehouse can be seen in the glacially striated outcrop on the north side of Route 20. Returning to the Seneca, it can be seen that the unit consists of a sequence of depositional cycles of cross-stratified, coarse-grained grainstone tempestites overlain by fine-grained packstones. The Seneca does not show a fining upward trend at this locality and is abruptly overlain by the black Union Springs Shale of the Marcellus Formation. This contact is interpreted as a minor erosional unconformity.

At end of stop, continue east on Route 20.

78.6 Turn right onto Chestnut Street and immediately head west toward Cherry Valley on side road parallel to Route 20.

78.65 Park next to long roadcut.

STOP 3 Cherry Valley Limestone and associated carbonates: Regional shoaling in a euxinic black shale basin (CEB, GK) (15 minutes).

This large roadcut exposes a critical interval in the lower Hamilton Marcellus Formation. Three members are present; in ascending order these are the Union Springs Shale, Cherry Valley Limestone and lower part of the Chittenango Shale. The section is near the type locality of the Cherry Valley Limestone and provides an excellent look at that somewhat unusual goniatite-rich carbonate interval and the condensed sequence of concretionary carbonates in the subjacent upper Union Springs shale. Previous discussions of this section include those of Rickard (1952), Cottrell (1972), Fisher (1979) and Bosworth (1984a, b).

At end of stop, return to Route 20 and continue east.

81.05 Re-enter Leesville and descend through cuts in Kalkberg Limestone.

82.35 Re-enter Village of Sharon Springs.

82.85 Pass through intersection with Route 10 and continue east on Route 20.

84.7 Enter Village of Sharon Center. Pass through low roadcuts of Onondaga Limestone approximately 0.5 km further down road.

86.05-86.25 Ascend hill with roadcuts in the Onondaga Limestone.

87.8 Enter Village of Sharon.

88.05 Turn right (south) onto New York Route 145 at blinking traffic light.

91.85 Intersection with Schoharie County Route 11 on the north (left). The contact of the Onondaga Limestone with the black shales of the overlying Marcellus Formation is exposed in the intermittent creek along the south shoulder of Route 145. The contact lies approximately 500 m east of the intersection with Route 11.

92.15 Enter Town of Cobleskill.

92.95 Enter Village of Lawyersville, New York.

93.25 Turn left (east) at stop sign in Lawyersville.

94.3 Enter Village of Cobleskill, New York.

95.2 Merge with New York Route 10 in Cobleskill.

95.5 Continue on Route 145 south, turn left at traffic light.

96.6 Continue on combined Routes 7 east and 145 under railroad overpass.

98.9 Turn right (south) onto Route 145 at traffic light.

99.1 Pass underneath U.S. Interstate 88 overpass; turn left onto access ramp to Interstate 88 (East). Stay in right lane.

99.45-99.8 Park next to long roadcut with prominent black shales, begin examination of section from base.

STOP 4 Section from Becraft Limestone through lowest Onondaga Limestone (EL) (30 minutes).

This long road cut exposes an excellent section from the upper part of the Becraft Limestone through the lowest portion of the Onondaga LImestone in the woods at the top of the roadcut. The medium- to thick-bedded, coarse-grained crinoid grainstones of the Becraft are abruptly overlain by ca. 1.5 m of calcareous, coarse-grained quartz arenites of the Oriskany Sandstone with a large, thick-shelled brachiopod-dominated fauna. Large trough sets occur in the middle of the Oriskany ledge. The Oriskany Sandstone-Esopus Shale contact is abrupt. *Zoophycus* burrows up to 0.5 m in diameter weather out on the top of the Oriskany and suggest that Esopus mud was worked into the well-washed Oriskany sand by these burrowers. The Esopus ranges from a dark grey-green to black mudstone to shale with sparse *Planolites* and *Zoophycus* burrows. This ca. 15 m of dark mudstone is abruptly overlain by orange-brown weathering finegrained quartz arenites of the Carlisle Springs Formation about half-way up the road cut. *Zoophycus* and arthropod scratch marks are particularly abundant at the contact and include *Z. cauda-galli* traces to 0.75 m in diameter. The contact of the Carlisle Springs and overlying Onondaga Limestone is covered below the weathered Onondaga ledges at the top of the roadcut.

Descend hill and proceed a short distance east down Interstate 88 for Stops 5-7.

The general purpose of Stops 5, 6 and 7 is to apply the hypothesis of punctuated aggradational cycles (Goodwin and Anderson, 1985) to a variety of Cayugan and Helderbergian facies. Specific objectives include:

1. Demonstration that the entire sequence, including tidal flat through deep shelf facies, consists of punctuated aggradational cycles.
2. Evaluation of a PAC column by participants at Stop 7 (Cobleskill, Rondout and Manlius Formations).
3. Demonstration and discussion of cycle dynamics based on outcrop observations.
4. Demonstration of relationship of small-scale cycles to traditional stratigraphic units (i.e. formations and members).
5. Demonstration of the response of faunal associations to stratigraphic cyclicity.

In this manner we will present evidence that stratigraphic analysis of the Upper Silurian – Lower Devonian sequence from an episodic perspective is significantly different from previous analyses conducted under models of stratigraphic gradualism (EJA, PWG).

100.4 Park below high road cut on east side of Interstate 88.

STOP 5 Roadcut in Kalkberg Formation through Becraft Limestone (EJA, PWG) (20 minutes).

This locality is situated at the position on Rickard's (1962) cross-section where he shows an interfingering of Kalkberg and New Scotland facies (Figure 4A). Rickard's formational units can be recognized on our columnar section, which is a preliminary description of the interval as a sequence divisible into PACs. At this stage we are able to recognize major punctuation events and some individual PACs but have yet to develop criteria for recognition of PACs in some of these deep shelf facies.

By matching patterns of major punctuation events and certain key facies changes we have established correlations with the Helderberg sequence in the Hudson Valley (see right side of Figure 6). Specifically, the Coeymans-Kalkberg formational boundary (Punctuation Event B) at Stop 5 correlates with the punctuation event that initiated Broncks Lake (upper Kalkberg) deposition in the Hudson Valley. Major punctuation event C is the same event which initiated New Scotland deposition in the Hudson Valley. Punctuation event D is also recognizable in the Hudson Valley within the New Scotland Formation as an event that initiated a second sequence of carbonate turbidites, the deepest facies in this part of the Helderberg Group.

At this locality and in the Hudson Valley our correlations indicate that the Becraft-Alsen contact is a synchronous surface produced by punctuation event E and that the Oriskany-Esopus contact is also produced by a single punctuation event (G) in both areas. The Alsen-Oriskany contact in the Schoharie region is not a simple PAC boundary; rather it is a regional unconformity. Punctuation event F caused flooding of the erosional surface in this area.

Correlation of these major punctuation events establishes that this middle and upper Helderberg sequence accumulated episodically, not gradually and continuously as previously interpreted (Laporte, 1969; Anderson 1972). Deep shelf facies occur repeatedly, immediately above major punctuation events C and D, and are separated by shallower shelf facies. Also, the general shallowing into Becraft facies is accomplished episodically and is terminated by the major punctuation event at the Becraft-Alsen boundary.

At end of stop, continue east on Interstate 88.

100.95 Stop next to low cut in massive limestone off east shoulder of road.

STOP 6 Upper part of the Coeymans Limeston (EL) (10 minutes).

The purpose of this brief stop is to examine a characteristic facies from the upper portion of the Coeymans Limestone. The ca. 1.5 m-thick section is composed of medium bedded, light grey weathering, crinoid packstones and thin, very calcareous shaly intercalations. The section has undergone a long interval of weathering and partially silicified favositid corals are exposed in considerable relief along the outcrop. Several of these colonies have been overturned during deposition of the limestone.

At end of stop, proceed further down Interstate 88 and park near base of lowest road cut along this stretch of road.

103.1 Park near base of long, high section in Upper Silurian and Lower Devonian carbonates.

STOP 7 Cobleskill, Rondout (Chrysler Member), Manlius (Thacher Member) and Coeymans Formations (EJA, PWG) (90 minutes).

The Cobleskill-Rondout-Manlius interval (26 meters thick) is completely divisible into 13 or 14 PACs which are assigned numbers reflecting correlations with the Hudson Valley sequence (Figure 5). The Cobleskill Formation is itself a single PAC (PAC 2) initiated by a major punctuation event which flooded the erosion surface on the Brayman Shale (see water depth curve). A second major punctuation event initiated Rondout deposition; our correlations with the Hudson Valley suggest that this event initiated Glasco deposition in that region. The 4 or 5 Cobleskill-Rondout PACs comprise a sequence of peritidal cycles terminated by the major punctuation event represented by the Rondout-Manlius boundary. This event terminated tidal-flat deposition and initiated a sequence of subtidal PACs in the lower Manlius Formation.

Within the sequence of 9 Manlius PACs, the boundary between PAC 12 and PAC 13 is unique. At this boundary, the upper part of PAC 12 is marked by a laminated cryptalgal crust on a scalloped surface, features which suggest subaerial exposure and erosion resulting from a minor sea-level fall. This surface is a widespread marker horizon traceable throughout the Hudson Valley. The subsequent sea-level rise created water depths sufficient to produce the subtidal, bioturbated, stromatoporoid-bearing limestones of PAC 13. Another significant punctuation event resulted in even greater water depth and the diversely fossiliferous subtidal facies of PAC 14. PAC 15 is like PAC 14 but is truncated by an unconformity.

The Manlius-Coeymans boundary is a surface with a complex history. At Schoharie, at the top of Manlius PAC 15 (Figure 5), it appears to be a normal PAC boundary marking a major punctuation event which introduced facies very different from Manlius facies below. However, correlation of PACs to the east and south indicate progressive erosion and elimination of PAC 15, 14 and 13 in the Hudson Valley as a result of differential uplift. This erosional surface was then inundated by a sea-level rise which initiated Coeymans deposition throughout the area (Goodwin et al, 1986).

This episodic stratigraphic history of the Cobleskill-Coeymans interval is significantly different from earlier interpretation (e.g. Rickard, 1962; Laporte, 1969) in which the sequence was viewed as gradually and continuously transgressive. Not only do we recognize environmentally significant discontinuities at every PAC boundary, the Manlius-Coeymans formational boundary is also revealed as an unconformity rather than an environmental boundary produced by lateral migration of contiguous facies. Finally, the difference in interpretations can be illustrated by focusing on the facies trends within formational units. Stratigraphic gradualism predicts upward deepening through each formational unit during gradual transgression. Instead, episodic deepening and recurrent shallowing are the observed trends (see water-depth curve). For example, the deepest Cobleskill-Rondout facies are at bases of PACs low in the interval; the shallowest facies occur at the top of the Rondout. Likewise, a geographically persistent sea-level surface (top of PAC 12) occurs high in the Manlius. Such patterns are consistent with the predictions of the PAC hypothesis but incompatible with the predictions of stratigraphic gradualism.

At end of Stop 7, continue east along Interstate 88.

104.75 Cross Schoharie Creek at bottom of long grade. Low exposures of thick-bedded sandstones of the Schenectady Formation (upper Middle Ordovician) occur to the southeast of Route 88 at the base of the Helderberg escarpment.

105.6 Exit Interstate Route 88 at the Central Bridge/Schoharie interchange. Turn right onto New York State Route 30A (south).

106.05 Intersection with New York State 30, take Route 30 toward Schoharie (south).

107.4 Junction with New York Route 443; turn left (east) onto Route 443.

108.3 Stop sign, continue on Route 443.

109.65 Enter hamlet of Sutters Corners.

111.1 Enter Village of Gallupville, New York. Continue on Route 443 through intersection with Route 146.

114.85 Enter Albany County and Town of Knox.

115.25 Enter Village of West Berne, New York.

116.2 Intersection with Albany County Route 254 on left. The hills to the north (left) are underlain by limestones of the Helderberg Group while the Hamilton Group siliciclastics form the terrane to the south.

116.8 Intersection with Albany County Route 1 (Switz Hill Road) and cross Fox Creek.

117.45 Quarry on right and adjacent to highway department garage is in the Onondaga Limestone.

117.52	Turn right onto Albany County Route 9.
118.15	Stop sign and intersection with Albany County Route 1. Turn left onto Route 1.
123.7	Enter Village of South Berne, New York.
125.5	Intersection with Albany County Route 2, continue south (right) on Route 1.
125.6	View of the High Peaks region of the Catskill Mountains to the south.
126.5	Intersection with New York State Route 85, turn right onto Route 85.
126.9	Sandstones and siltstones on south side (left) of road are in the Mount Marion Formation.
127.5	Intersection at crossroad with Albany County Route 408, continue through intersection.
128.6	Park in vicinity of Shell Inn and walk up dirt track to shale pit on south side of road.
STOP 8	Mount Marion "beds," marginal marine deposits of the lower part of the Hamilton Group (CEB, EL) (30 minutes).

This small borrow pit exposes about 6.5 m of the upper Marcellus Otsego Shale member (or Mount Marion beds, these two units are intergradational in this region of the Berne Quadrangle; see Cooper, 1934, Goldring, 1935). The lowest exposures consist of a layer of hard, fine grained quartz arenite about 6 m above road level. The lower 3.9 m in the quarry consist of highly fossiliferous, dark grey, brownish weathering, silty shales and siltstones with abundant small, ellipsoidal sideritic nodules. These shales yield a diverse Hamilton fauna, dominated by brachiopods (e.g. *Productella*, *Spinocyrtia*, chonetids) fenestellid and *Taeniopora* bryozoans and bivalves (*Ptychopteria*, *Grammysia*, *Goniophora*). Faunal assemblages of this section suggest an early Givetian age for this sequence. Although most fossils are moldic, many are well articulated (e.g. crinoid columns, bivalved shells), indicating rapid burial and minimal transport. Many bivalves are represented by complete, slightly compressed steinkerns, indicating some induration of shell-filling muds prior to compaction. These "pressure shadow" steinkerns are probably related to the formation of the sideritic nodules with which they co-occur. This brachiopod-bivalve assemblage reflects shallow but perhaps turbid water conditions on the seafloor.

A thin (5-10 cm) coral-rich horizon occurs about at 7.6 m above road level (1.5 m above base of exposure) in the eastern portion of the pit. This unit contains scattered large rugose corals (e.g. *Cystiphylloides*, *Heliophyllum*), and a few scattered large heads of *Favosites*. Corals display little corrasion and some are preserved in probable life orientation. This unit represents the *Meristella*-coral bed (see Cooper, 1934, p. 549; Oliver, 1951) which has been traced southward along the Hudson Valley at least to Kingston, New York within the lower Mt. Marion Formation. A possible lateral equivalent of the bed has been discovered in the lower Oatka Creek-Chittenango shale of western and central New York State (Baird and Brett, unpublished); the latter unit is characterized by a diverse brachiopod fauna and small auloporid corals although none of the larger rugosans are present. If this correlation is correct the *Meristella*-coral horizon records an extremely widespread depositional episode in the lower Hamilton Group. The abundance of corals suggests clear, shallow water and we suggest that the *Meristella*-coral bed represents the cap of a small-scale but widespread shallowing cycle in the post-Cherry Valley Marcellus.

Higher beds in the quarry show a brief return to the brachiopod-bivalve community but this passes upward into 2.6 m of sparsely fossiliferous, flaggy siltstones which are locally quite pyritic but contain few fossils other than carbonized plant fragments. The section here is capped by a 20 cm thick bed of rippled quartz arenite with a rippled upper surface and sparse plant fragments. On the whole, this sequence appears to record local shoaling of the late Marcellus seafloor due to progradation. Nearby sections indicate a passage to nearly nonmarine redbeds slightly above these flagstones. The abundance of plant detritus indicates proximity of this site to some of the oldest fossil forests that grew along the flanks of the Catskill Delta.

At end of stop, return east along Route 85; this is the last field trip stop.

130.8	Re-cross intersection with Albany County Route 1.
136.5	Junction with New York Route 443, continue on Route 85-443.
138.5	Routes 85 and 443 diverge, continue left on Route 85.
138.8-139.3	Route passes by outcrops of the Moorehouse Member of the Onondaga Limestone.
139.5	Roadcut on left side of route includes the lower part of the Edgecliff Member and continues downhill through the Schoharie Formation.
141.5	Village of New Salem, New York.
144.4	Enter Village of New Scotland, New York.
145.5	Junction with Route 85A at traffic signal, continue on Route 85.

151.9	Turn right onto access road to Route 20; continue on Route 20 east (Western Avenue) to the New York State Museum.
155.25	Return to Cathedral Parking Lot; end of trip.

146.75	Enter Village of Slingerlands, New York.
148.4	Junction with New York State Route 140.
148.95	Turn left at traffic signal and continue on Route 85.

Stratigraphy and Sedimentology of the Chazy Group (Middle Ordovician)–Lake Champlain Valley

Stephen E. Speyer
Department of Geology, University of Alberta
and Bruce W. Selleck
Department of Geology, Colgate University

SUMMARY

This trip features field stops in the Chazy Group at Crown Point, New York, and Isle La Motte, Vermont (Figure 1). The stops will allow participants to examine (a) lithologies and faunas of both biostromal and non-biostromal facies of the Chazy; (b) stratigraphic and facies changes along the north-south Champlain Valley outcrop belts; and (c) contact relationships with the underlying Providence Island Dolostone (Beekmantown Group) at Isle La Motte and the overlying Black River Group at Crown Point. We will also explore various aspects of the sedimentology and sedimentary petrology of the Chazy Group.

REGIONAL SETTING

The early Middle Ordovician Chazy Group crops out from the southern Lake Champlain Valley to the vicinity of Arnprior, Ontario, in the Ottawa River Valley. The outcrop can conveniently be subdivided into a north-south Lake Champlain Valley belt and a northwest-southeast Ottawa Valley-Montreal belt. In the Lake Champlain Valley, undeformed Chazy Group strata occur in a series of normal fault-bounded areas bordered by the Proterozoic Adirondack massif. East of the Champlain Valley, the Chazy Group is present in erosional windows through Taconic thrust sheets (Cady, 1945; Welby, 1961) and in fault slivers at the base of the Taconic Frontal Thrust (Selleck and Bosworth, 1985). Taconian deformation destroyed the primary textures and fabrics of Chazy strata in the eastern portion of the Middlebury synclinorium. In the Montreal area, a number of quarries and outcrops provide excellent exposure (Hoffmann, 1963, 1982). Outcrops of the Chazy occur in cliff-face exposures near the Ottawa River from Hawkesbury to Arnprior, Ontario. Rapid appearance of arkosic sandstones in the Ottawa-Arnprior area suggest that a terrigenous clastic source terrane was located to the west in central Ontario (Hoffmann, 1972). The Ottawa River outcrop belt is bordered on the north and northeast by the Proterozoic Grenville Province, and on the south-southwest by younger strata.

Chazy Group strata disappear from the autochthonous Cambrian-Ordovician stratigraphy south of the latitude of Hubbarton, Vermont. Chazy-correlative units reappear in northern New Jersey (Savoy *et al.*, 1982). This belt lacking Chazy strata roughly corresponds to the position of the so-called New York Promontory of Rodgers (1975) and suggests that this portion of the Ordovician margin of eastern North America was a positive feature during Chazy Group deposition.

Through the area of its exposure, the Chazy Group overlies dolostones of the upper part of the Beekmantown Group (Providence Island Dolostone and Bridgeport Formation in the Champlain Valley; Oxford and Beauharnois Formations in Ontario and Quebec), and is overlain both conformably and disconformably by the basal dolostones of the Black River Group (Orwell Limestone in southern Lake Champlain Valley; Pamelia Formation of the northern Lake Champlain Valley, Quebec and Ontario) (see Figure 2). The maximum total thickness of the Chazy Group is approximately 300 meters in the northern Lake Champlain Valley (Fisher, 1968), but thins south to about 100 meters near Crown Point proper (Shaw, 1968).

STRATIGRAPHY

Emmons (1842) assigned the name Chazy to fossiliferous limestones in the vicinity of Chazy Village in Clinton County, New York. Further stratigraphic work in the Lake Champlain Valley by Brainard and Seeley (1896), Cushing (1905), Raymond (1905), Grabau (1909), Cady (1945), Erwin (1957) culminated in the report by Oxley and Kay (1959) in which a locally workable internal stratigraphy was presented. Cushing (1905) established a threefold subdivision of the Chazy consisting of the Day Point, Crown Point and Valcour Formations. Further member-level subdivision was developed by Oxley and Kay (1959) for the northern Lake Champlain Valley. Cady (1945) assigned Chazy strata in west-central Vermont to the Day Point, Crown Point and Valcour, but noted that the units differed from supposed equivalents in the northern Lake Champlain Valley. The Middlebury Limestone was defined by Cady as equivalent to the entire Chazy Group in the Middlebury Synclinorium. Fisher (1968, 1977) summarized the biostratigraphy of the Chazy in New York.

The stratigraphy of the Chazy Group in the Montreal-Ottawa area has been investigated by Clark (1934, 1952), Cooper (1956), Wilson (1946) and most recently by

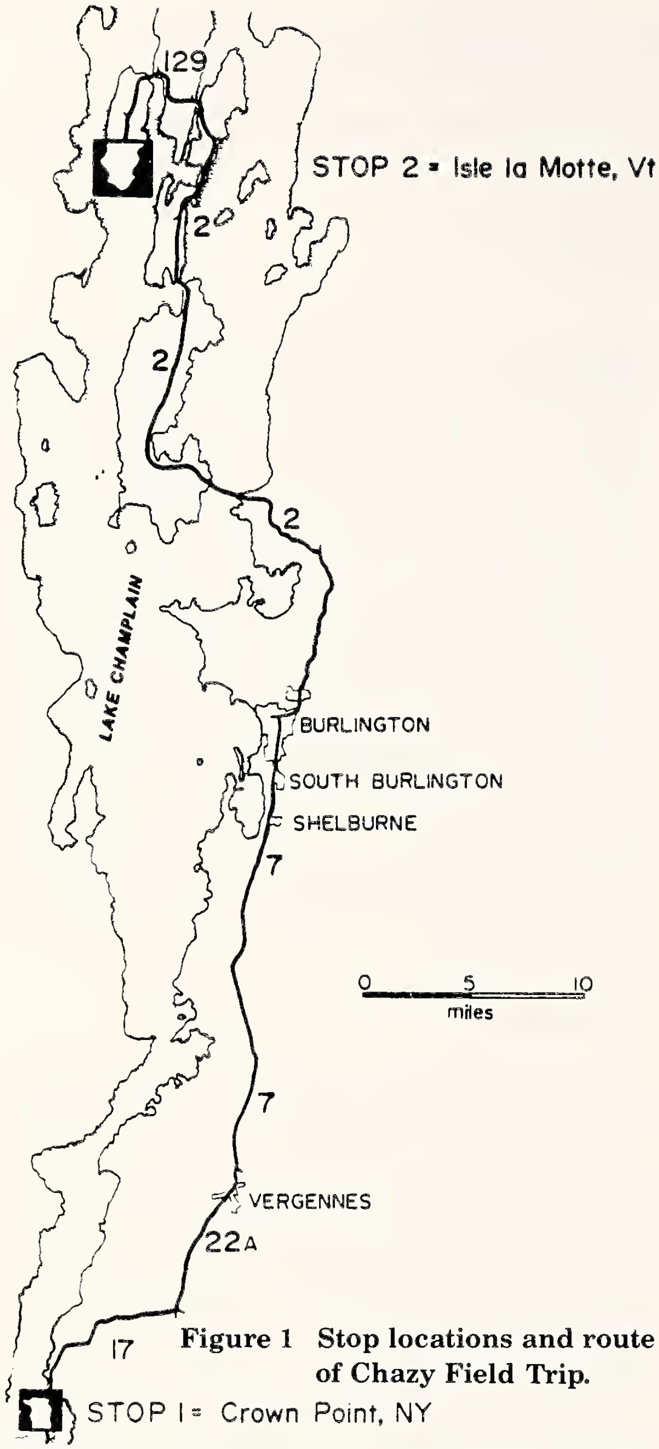


Figure 1 **Stop locations and route of Chazy Field Trip.**

Hoffmann (1963, 1972, 1982). In general, these workers have utilized a twofold subdivision of the Chazy, consisting of a basal terrigenous clastic-rich unit (St. Therese Member in Montreal region, Rockcliffe Formation in the Ottawa region) and an upper, carbonate dominated unit (Laval Formation in Montreal area, St. Martin Formation in Ottawa area). Both Hoffmann (1963) and Oxley and Kay (1959) noted the considerable lateral changes in thickness and lithology within their study areas and provided schematic isopach maps for the Ottawa-Montreal and Lake Champlain areas, respectively.

Given the abundant lateral facies changes present in the Chazy Group, it is clear that the member-level subdivisions of Oxley and Kay (1959) are applicable only in the northern Lake Champlain Valley (see Figure 2). Fisher (1968, 1977) retained the three-fold formation-level subdivision of Cushing. However, these units are not specifically identifiable in either the Ottawa-Montreal area nor the southern Lake Champlain Valley (Shaw, 1968).

BIOSTRATIGRAPHY

Biostratigraphic correlations of the Chazy Group have been attempted using brachiopods (Cooper, 1956), trilobites (Shaw, 1968) and conodonts (Raring, 1972; Roscoe, 1973). Correlations based upon macrofauna have been, to date, ambiguous and of limited practical use. The reasons for this include a basic incompatibility between different fossil taxa, an incomplete understanding of facies diversity (and hence, biofacies distribution) and absence of suitably comparable facies in other regions which reflect environmental conditions similar to those inferred for Chazy facies. It is likely, however, that correlations based upon microfauna will be useful in diagnosing facies relationships among the trilobite, brachiopod and other large, shelly taxa.

Raring (1972) and Roscoe (1973) provided the only detailed analyses of Chazy Group conodont biostratigraphy that are presently available. With the exception of certain fine points of clarification, these two workers generally agree that the Chazy Group is divisible into four conodont zones. Chazy conodonts are dominantly of midcontinent character. *Eoplacognathus* n. sp (Raring, 1972) characterizes the lower portion of the Day Point Formation, through the lower Fleury Member. The lowest stratigraphic occurrence of this form was not specified by Raring and was left tentative by Roscoe. *Polyplacognathus friendvillensis* characterizes the uppermost Day Point Formation and lower-middle Crown Point Formation. *Polyplacognathus sweeti* ranges through the rest of the Crown Point and the lower and middle Valcour Formation. The upper Valcour is distinguished by *Cardiodella timidus* and *Plectodina aculeata*. Figure 3 summarizes these conodont zones with reference to Chazy Group strata in the Champlain Valley. In large part, Roscoe's (1973) and Raring's (1972) studies corroborate Kay's (1958) west-to-east correlations but are at odds with Cooper's (1956) synthesis.

Until recently, the Chazy Group served as the type section for the Chazyan Stage, which most workers placed between the basal Middle Ordovician Whiterockian Stage and the Middle Ordovician Mohawkian Stage (Cooper, 1956; Whittington, 1966). Ross et al. (1982) include the Chazy Group within the Whiterockian Series, but do not indicate divisional names for stages. The term "Chazyan Stage" is retained in their discussion.

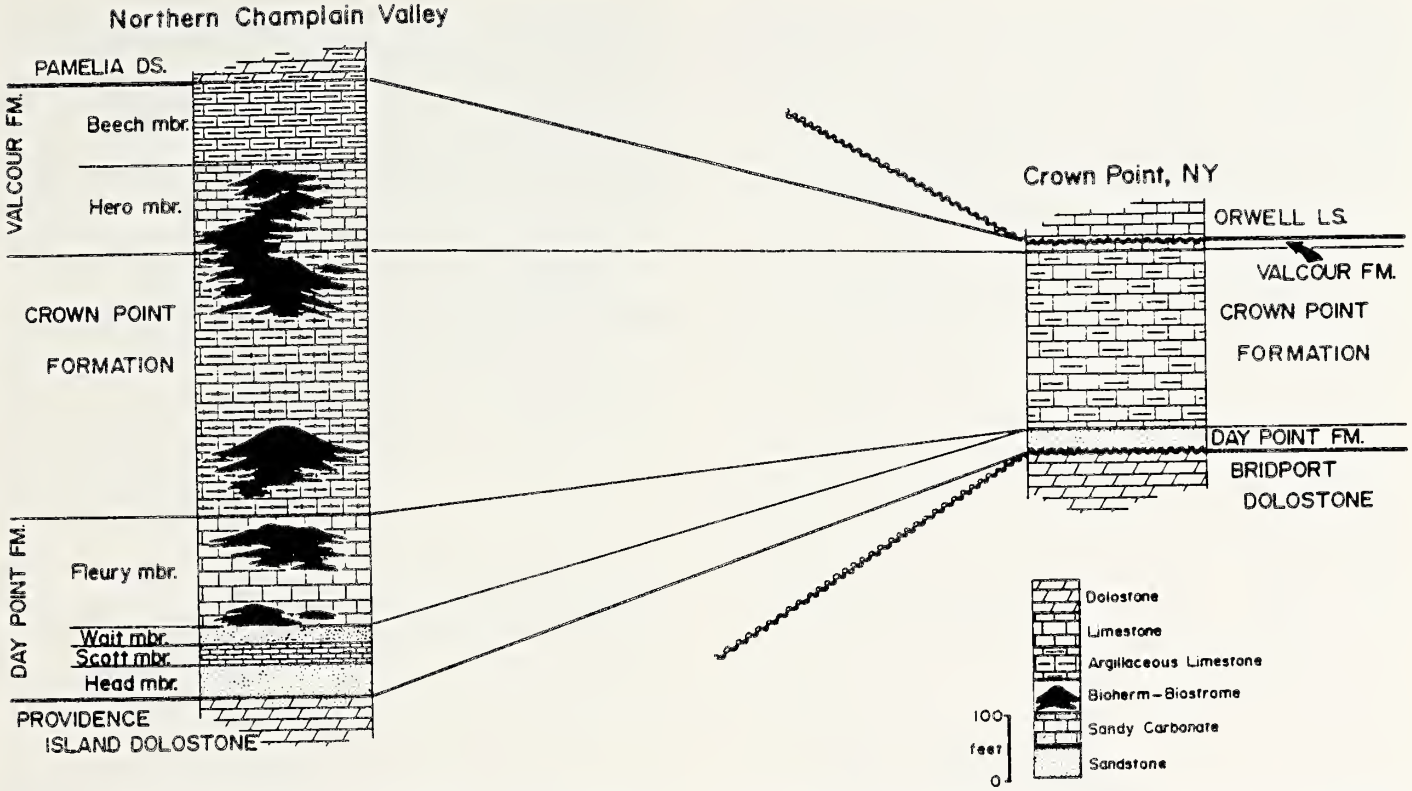


Figure 2 Generalized stratigraphy and lithologic correlations of Chazy Group strata in the northern Champlain Valley and at Crown Point, New York (modified from Shaw, 1968).

The inclusion of Chazy Group strata in the Whiterockian Series is poorly defended and does not involve direct correlations between Nevada strata above the type "Whiterockian" sequence and the Champlain region Chazy Group.

Welby (1961) provides a comprehensive synopsis of stratigraphic clarifications pertaining to the Chazy strata. In short, we prefer to use the Champlainian Series – Chazyan (=Montyan) Stage terminology and reserve Whiterockian as the earliest stage of the Middle Ordovician. Fisher (in Ross et al., 1982) suggests similar nomenclature, although this is largely ignored in the construction of Sheet 1 of that compendium (see Figure 3 for summary).

LITHOFACIES PATTERNS

Seven major lithofacies are present in the Chazy Group: (1) coarse feldspathic sandstones, (2) fine calcareous sandstones and siltstones, (3) green to grey silty shales, (4) dolomitic fossil-fragment packstones and wackestones, (5) burrowed and unburrowed carbonate "ribbon rock," (6) cross-stratified fossil grainstones, (7) algal-stromatoporoid-bryozoan-sponge boundstones.

(1) Coarse feldspathic sandstones: This facies consists of coarse sand- to granule-size, subrounded to well-rounded, moderately sorted feldspathic quartz sandstones (to 20 modal percent feldspar). In the Arnprior, Ontario area (Fitzroy Harbor section) this facies occurs as unfossiliferous large-scale planar-tabular cross-strata interbedded with reddish sandy mudstones (nonmarine facies of Hoffmann, 1963). Elsewhere in the basal Chazy (Rockcliffe Sandstone, St. Therese Siltstone) of the Ottawa Valley-Montreal outcrop belt, the coarse sandstone facies occurs as 0.1-0.2 meter-thick interbeds within sections dominated by calcareous sandstones, siltstones and green-grey shales. Coarse feldspathic sandstones are present at the summit of the Chazy Group in the southern Lake Champlain Valley. Throughout the Ottawa-Montreal outcrop belt, coarse feldspathic sandstones occasionally grade laterally and vertically into lithofacies 6 (fossiliferous grainstones) on outcrop scale.

(2) Calcareous fine sandstones and siltstones: This facies is most common in the Day Point Formation (Head and Wait Sandstone Members) in the northern Champlain Valley and becomes dominant in the entire lower 1/2 of the Chazy Group (St. Therese Siltstone/Rockcliffe Sandstone) in the central Ottawa Valley. Thin- to medium-bedded ripple cross-laminated sandstones and siltstones, with subordinate trough cross-laminated medium-bedded sandstones, containing abundant phosphatic debris (lingulid fragments and phosphatic intraclasts and peloids) and interbedded with lithofacies 3 (silty shales), are typical. Sole markings (flute, groove and gutter casts) are common in some exposures; well-

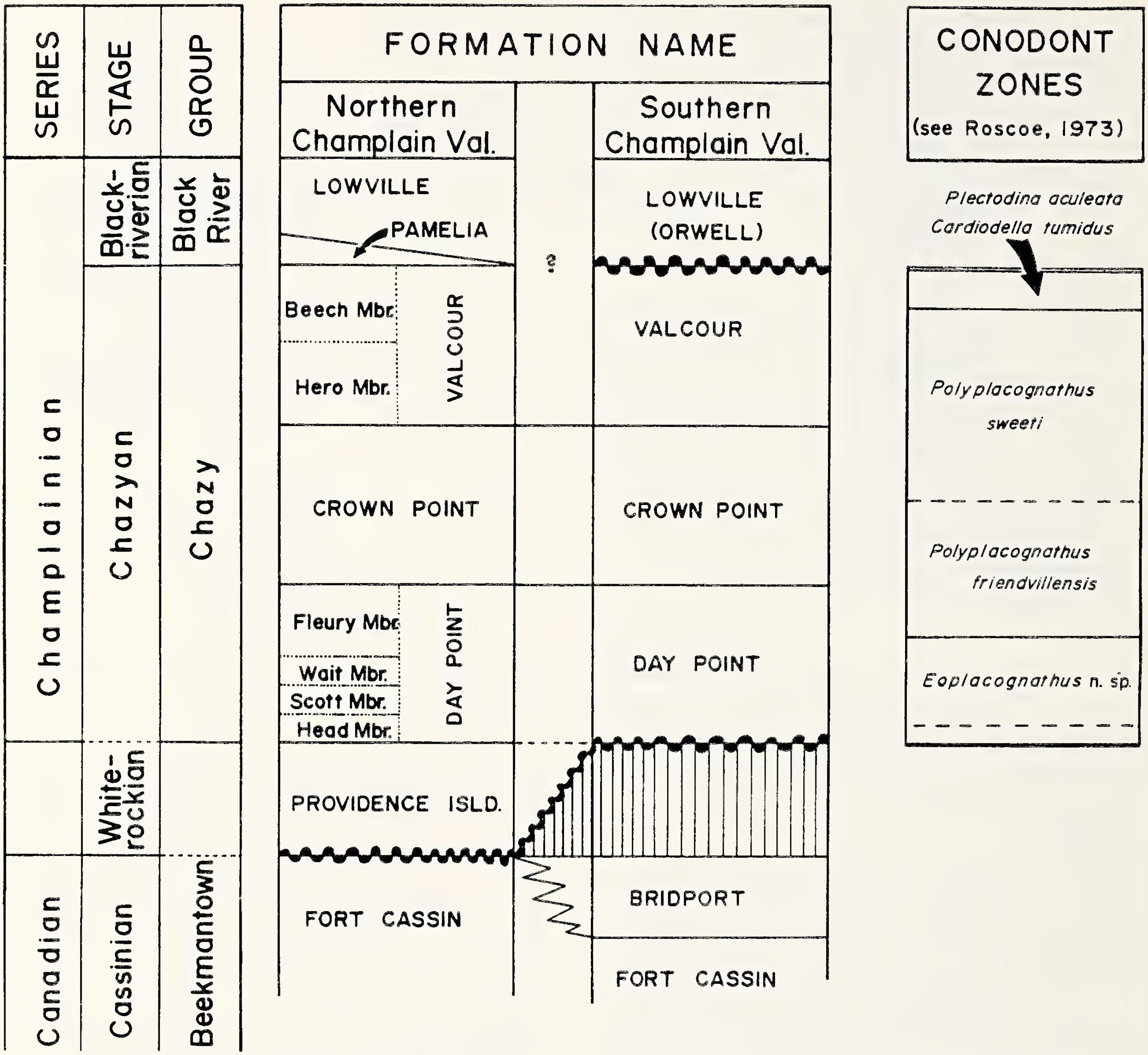


Figure 3 **Stratigraphic nomenclature, regional correlations and biostratigraphic zonation for Early and early Middle Ordovician strata in the Lake Champlain region of Vermont and New York State.**

preserved horizontal burrows and trails on sole surfaces are typical in eastern Ottawa Valley exposures (Hoffmann, 1979). In the Ottawa area, bioturbated calcareous fine sandstones are rhythmically interbedded with the typical laminated facies in 1.0-1.5 m units.

(3) Green and grey silty shales: This facies occurs as thin (1-3 cm) interbeds associated with facies 1 and 2 in the central Ottawa Valley and as somewhat thicker (5-20 cm), generally grey-colored units in the basal Laval Formation in the Montreal area. Thin shale interbeds occur sporadically in sections dominated by lithofacies 4 (bioclastic packstones and wackestones) throughout the study area. Facies 3 generally lacks a macrofauna with the exception of rare ostracodes.

(4) Dolomitic fossil fragment packstones and wackestones: This facies is dominant in the Crown Point and lower Valcour Formations of the northern Lake Champlain Valley and abundant in the southern Lake Champlain (Crown Point Formation) and Montreal (Laval Formation) area sections. Dolomite is present as thin, irregular shaley stringers and stylocumulate seams, and as a replacement of burrow-fill material in medium-bedded, fossil packstones and wackestones. In some exposures, dolostone may form 75-90 percent of the rock

with isolated "islands" of lime packstone or wackestone in an otherwise dolomite rock. Truncated grains on bedding surfaces and bored hardgrounds document the influence of early cementation in many sections. This facies contains the most abundant and diverse non-biostromal faunal assemblages in the Chazy Group. Bryozoans, brachiopods, trilobites, nautiloids, the gastropod *Maclurites magnus* and algal oncolites ("*Girvanella*") are present as fossil fragment constituents. Micrite peloids and intraclasts also are present. Lime mud matrix is common and fabrics vary from mud to grain supported. Horizontal and vertical burrows are common. In the Crown Point Formation of the northern Lake Champlain, local stromatoporoid (*Cystostroma*, *Pseudostylodictyum*) boundstones occur within fossiliferous packstones of lithofacies 4.

(5) Burrowed and unburrowed ribbon rock: This facies is characteristic of portions of the upper Day Point Formation in the northern Lake Champlain Valley and occurs throughout the southern Lake Champlain Valley. This facies has not been identified in reconnaissance study of the Ottawa-Montreal exposures although terrigenous clastic analogues may be present in the Ottawa area within lithofacies 2. The most prominent features of facies 5 are 1-3 cm interbeds of dolostone and lime mudstone. These strata exhibit a striking "ribbon" lamination on weathered surfaces and strongly resemble the ribbon limestone facies of the St. Paul Group (Chazy Group equivalent) described by Matter (1967) and the Late Cambrian Conococheague Limestone described by Demicco (1983). Internally, dolomite lamina consist of meso-crystalline, idiotopic dolomite crystals that partially to totally replace fine-sand-size micritic peloids in thin-section. Limestone laminae consist of silt-size carbonate peloids and lime mud. Dolomite laminae often preserve small-scale ripple cross-lamination and millimeter-scale plan laminae. In many exposures, the alternating dolostone/limestone fabric is organized into low-angle sets of trough-cross strata that measure 5-80 cm in thickness. This cross-stratification was apparently produced by draping of the ribbon fabric sediment onto an irregular, channeled erosion surface. Lateral accretion cross-strata may also be present. Poorly sorted bioclastic grainstone beds occupy the floors of small scours in ribbon rock. Intraclast conglomerates are locally abundant on scoured surfaces suggesting an event-related derivation. Faunal diversity in this facies is very low with *Maclurites magnus* the only abundant form. The ribbon fabric is often transected by small (2-5 cm length) vertical burrows; organized, traces of infaunal deposit(?) feeders (*Chondrites* networks) are sporadically present. Burrowed and unburrowed ribbon rock subfacies tend to occur in alternating 0.5-1.5 m units in outcrop. Unburrowed ribbon rock has been observed to fill solution-erosion (microkarst?) surfaces in underlying burrowed ribbon rock (similar surfaces have been described by Read and Grover, 1977).

(6) Bioclastic grainstones: Medium- to coarse sand-size fossil fragment grainstones occur prominently in the middle and upper Day Point Formation in the northern Champlain Valley and in the upper Laval Formation of the Montreal area. Grainstone beds also are common in the central Ottawa Valley sections and occur sporadically in southern Lake Champlain Valley exposures. Grainstones typically flank bioherms in the upper Day Point and lower Valcour Formations in the northern Champlain Valley. In general, the grainstones consist of abraded shell debris (pelmatozoan and molluscan fragments dominate); ooliths are present in the Day Point Formation grainstones of the northern Lake Champlain Valley. Intraclasts, peloids, and oncolites are common, and scattered quartz and feldspar grains are typical. A variety of types of crossstratification are present, including spectacular large-scale planar, tabular and trough sets. Bipolar dip directions are commonly observed.

Grainstones in the Ottawa-Montreal sections are interbedded, and locally grade into facies 1 coarse sandstones and are associated with facies 4 packstones and grainstones and facies 2 silty shales. In the central and southern Lake Champlain Valley, grainstones are associated with both facies 4 and facies 5 (ribbon rock).

(7) Boundstones: The well developed "reefs" for which the Chazy Group is most well-known occur largely within the upper part of the Day Point (Fleury Member) and lower part of the Valcour Formations (Hero Member) of the northern Lake Champlain Valley and in the Laval Formation of southern Quebec. Smaller boundstone structures also occur in the Crown Point Formation in the northern Champlain Valley.

Chazy Group boundstones locally formed significant topographic structures (true "reefs") flanked by coarse grainstones of facies 6. The major binding elements of the fauna include calcareous algae (*Solenopora*, *Sphaeocodium*, "*Girvanella*"), stromatoporoids (*Cystostoma*, *Pseudostylodictyum*), lithistid sponges (*Zittilella*, *Anthaspidella*), tabulate corals (*Lamottia*, *Billingsaria*, *Eofletcheria*[?]), and bryozoans (*Batosoma*, *Cheiloporella*, *Atactotoechus*) (Finks and Toomey, 1972). A diverse associated fauna consists of numerous trilobites, nautiloids and brachiopods.

The confinement of Chazy Group boundstone structures to the northern Champlain Valley of New York, Vermont and southern Quebec may be due to a combination of relatively turbulent conditions, open marine circulation and appropriate substrate development. The occurrence of these structures within the stratigraphically thickest section of the Chazy suggest that basement subsidence was in some way a controlling factor.

PRELIMINARY FACIES INTERPRETATIONS

A schematic regional paleoenvironmental pattern emerges from interpretation of the depositional settings of the various lithofacies. The Chazy platform lay to the west of the Middle Ordovician shelf-slope break and developed upon a somewhat irregular topographic surface that was previously exposed to erosion and perhaps normal faulting during an interval of regional emergence (late Early Ordovician) (Fisher, 1977). The Ottawa Valley region (dominated by lithofacies 1, 2 and 3) received considerable terrigenous clastic input. Non-marine facies (portions of facies 1 and 2) may record braided stream or fan-delta environments. In the Ottawa-Montreal region, a somewhat restricted marine shelf (estuary??) received terrigenous sands and mud, with some carbonate production, during deposition of the lower Chazy Group (Facies 1, 2, 3, 4). Later Chazy Group deposition in the Ottawa-Montreal sections was dominantly carbonate (Facies 4, 6) but minor terrigenous input continued.

Terrigenous clastic input was considerably less overall within the Lake Champlain Valley region. Subtidal mud-sand environments with a diverse marine fauna (Facies 4), subtidal sand shoals (Facies 6), biostromes and reefs (Facies 7) and tidal flat environments (Facies 5) dominate in these sections. Vertical facies successions were produced by some combination of eustatic sea level fluctuations, basement subsidence and lateral migration of facies belts.

Specific environmental interpretations will be discussed in the context of the stop descriptions.

ACKNOWLEDGMENTS

Bruce Selleck gratefully acknowledges the assistance of Brewster Baldwin who first introduced him to the Crown Point Section. Stephen Speyer thanks Ed Landing who accompanied him on a field trip to measure the Providence Island Dolostone section exposed at The Head, Isle la Motte, Vermont. A Killam Research Support Grant (University of Alberta) enabled S. Speyer to lead the field trip.

REFERENCES CITED

Aigner, T. 1982. Calcareous tempestites: Storm dominated stratification in upper Muschelkalk limestones (Middle Trias, SW Germany). *In* Einsele, G., and Seilacher, A. (eds.), Cyclic and event stratification. Springer Verlag, New York, p. 180-198.

Baldwin, B. 1982. The Taconic Orogeny of Rodgers, seen from Vermont a decade later. Vermont Geol. 2:20-24.

Ball, M.M. 1967. Carbonate sand bodies of Florida and the Bahamas. J. Sed. Pet. 37:556-591.

Bathurst, R. 1971. Carbonate Sediments and Their Diagenesis. Elsevier Pub., New York. 659 p.

Brainard, E. and Seeley, H.M. 1896. The Chazy of Lake Champlain. Amer. Mus. Nat. Hist. Bull. 8:305-315.

Cady, W. 1945. Stratigraphy and structure of west-central Vermont. Bull. Geol. Soc. Amer. 56:515-588.

Churkin, M., Carter, C., and Johnson, B. 1977. Subdivision of Ordovician and Silurian time scale using accumulation rates of graptolitic shale. Geol. 5:452-466.

Clark, T.H. 1934. Structure and stratigraphy of southern Quebec. Geol. Soc. Amer. Bull. 45:1-20.

__________ 1952. Montreal area-Laval and Lachine map areas. Can. Dept. Mines Geol. Rept. 46, 159 p.

Cooper, G.A. 1956. Chazyan and related brachiopods. Smithsonian Misc. Coll. 127, 1024 p.

Cushing, H. P. 1905. Geology of the Northern Adirondack Region (New York). New York State Mus. Bull. 95:271-453.

Demicco, R.V. 1983. Wave and lenticular-bedded ribbon rocks of the Upper Cambrian Conococheague Limestone, Central Appalachians. J. Sed. Pet. 53:1121-1132.

Emmons, E. 1842. Geology of New York, Part 2. Comprising the survey of the Second Geological District, 437 p.

Erwin, R.B. 1957. The geology of the limestone of Isle la Motte and South Hero Island, Vermont. Vt. Geol. Surv. Bull. 9, 94 p.

Finks, R.M., Shaw, F.C., and Toomey, D.F. 1972. Ordovician paleontology and stratigraphy of the Champlain Islands. *In* Doolan, B.L. and Stanley, R.S. (eds.), Guidebook for field trips in Vermont. New Engl. Intercoll. Geol. Assoc., 64th Ann. Meeting, p. 429-442.

__________ and Toomey, D.F. 1972. Paleoecology of chazy reef-mounds. *In* Doolan, B.L. and Stanley, R.S. (eds.), Guidebook for field trips in Vermont. New Engl. Intercoll. Geol. Assoc., 64th Ann. Meeting, p. 443-472.

Fisher, D.W. 1968. Geology of the Plattsburgh and Rouses Point, New York-Vermont Quadrangles. New York State Mus. Map and Chart Ser. 10, 51 p.

__________ 1977. Correlation of the Hadrynian, Cambrian and Ordovician rocks in New York State. New York State Mus. Map and Chart Ser. 25, 75 p.

Grabau, A.W. 1909. A revised classification of the North American Lower Paleozoic. Science 29:351-356.

Hall, J. 1847. Palaeontology of New York, v. 1, Albany, N.Y., 338 p.

Hoffmann, H.J. 1963. Ordovician Chazy Group in southern Quebec. Amer. Assoc. Pet. Geol. Bull. 47:270-301.

__________ 1972. Stratigraphy of the Montreal area. 24th Int. Geol. Cong., Montreal. Guidebook for Excursion B-03, 32 p.

__________ 1979. Chazy (Middle Ordovician) trace fossils in the Ottawa-St. Lawrence Lowlands. Geol. Surv. Can. Bull. 321:27-59.

____________ 1982. Middle and Late Ordovician fossiliferous rocks of the Montreal area. 3rd North American Paleontological Convention, Montreal, Guidebook for Excursion D, p. D1-D39.

Kay, G.M. 1958. Ordovician Highgate Springs sequence of Vermont and Quebec and Ordovician classification. Am. J. Sci. 256:65-96.

Matter, A. 1967. Tidal flat deposits in the Ordovician of western Maryland. J. Sed. Pet. 37:601-609.

Oxley, P. and Kay, G.M. 1959. Ordovician Chazyan Series of the Champlain Valley, New York and Vermont. Amer. Assoc. Pet. Geol. Bull. 43:817-853.

Purdy, E.G. 1963. Recent calcium carbonate facies of the Great Bahama Bank. 2. Sedimentary Facies. J. Geol. 71:472-497.

Raring, A.M. 1972. Conodont biostratigraphy of the Chazy Group (Lower Middle Ordovician) Champlain Valley, New York and Vermont. Doctoral dissertation, Lehigh University, 58 p.

Raymond, P. 1905. The fauna of the Chazy Limestone. Amer. J. Sci. 20:353-382.

Read, J.F. and Grover, G. 1977. Scalloped and planar erosion surfaces, Middle Ordovician limestones, Virginia: Analogues of Holocene exposed karst or tidal rock platforms. J. Sed. Pet. 47:956-972.

Reineck, H. and Singh, I. 1980. Depositional Sedimentary Environments. Springer-Verlag, New York.

Rodgers, J. 1975. Appalachian salients and recesses. Geol. Soc. Amer. Abstracts with Programs 7:111-112.

Roscoe, M.S. 1973. Conodont biostratigraphy and facies relationships of the Lower Middle Ordovician strata in the Upper Lake Champlain Valley, Master's thesis, Ohio State University, 125 p.

Ross, R.J., Jr., and others. 1982. The Ordovician system in the United States of America. Correlation chart and explanatory notes. Int. Union Geol. Sci. Pub. 12, 73 p.

Savoy, L., Repetski, J., and Harris, A.G. 1981. Paleogeographic implications of the Lower/Middle Ordovician boundary, Northern Great Valley, eastern Pennsylvania to southwestern New York. Geol. Soc. Amer. Abstracts with Programs 13:174.

Selleck, B. and Bosworth, W. 1985. Allochthonous Chazy (Early Medial Ordovician) limestones in eastern New York. Tectonic and paleoenvironmental interpretation. Amer. J. Sci. 285:1-15.

Shaw, F.C. 1968. Early Middle Ordovician Chazy trilobites of New York. New York State Mus. Sci. Serv. Mem. 17, 163 p.

Speyer, S. 1982. Paleoenvironmental history of the Lower Ordovician-Middle Ordovician boundary in the Lake Champlain basin, Vermont and New York. Geol. Soc. Amer. Abstracts with Programs 14:85.

Sweet, W.C., Ethington, R.L., and Barnes, C.R. 1971. North American Middle and Upper Ordovician conodont faunas. *In* Sweet, W.C. and Bergstrom, S.M. (eds.), Symposium on conodont biostratigraphy. Geol. Soc. Amer. Mem. 127, p. 163-193.

Welby, C. 1961. Bedrock geology of the Central Champlain Valley of Vermont. Vermont Geol. Surv. Bull. 14, 296 p.

Whittington, H.B. 1966. Phylogeny and distribution of Ordovician trilobites. J. Paleont. 40:696-737.

Wilson, A. E. 1946. Geology of the Ottawa-St. Lawrence Lowlands, Ontario and Quebec. Can. Geol. Surv. Mem. 241, 65 p.

ROAD LOG

STOP 1 Crown Point Reservation Section.

The exposures at Stop 1 are located within Crown Point Reservation Historical Site, located on N.Y.S. Route 8, approximately 0.2 miles from the New York-Vermont border (Figure 4). From Ticonderoga, New York, proceed north on N.Y.S. Routes 9N and 22 through Village of Crown Point, New York, to intersection with Route 8. Proceed east on Route 8, following signs to Historic Site, Campground and Bridge to Vermont. Stop locations are keyed to map and columnar section. Stop 1A is in the ditch and wall of a small outpost fort on the east side of Route 8. No collecting is allowed in the historic area.

The outcrops on the northwest side of Route 8 traverse the upper one-half of the Chazy Group, the entire Black River Group and a portion of the Trenton Group (Figure 4). The section dips approximately 8° to the northwest.

Roscoe (1973) established the presence of conodont Fauna 6 of Sweet and others (1971) in the Chazy Group strata at Crown Point. On this basis, Roscoe correlated the uppermost Chazy strata at Crown Point with the Valcour Formation of the Northern Champlain Valley. Roscoe's (1973) Figure 5 clearly indicates that the collection was limited to the upper 50 feet of the Chazy section at Crown Point. Unfortunately, the lower Chazy section to the southeast of Route 8 was not sampled. The location of Raring's (1972) samples is unclear.

STOP 1A Outpost fort east of New York State Route 8.

Approximately 6 m of variously burrowed, slightly dolomitic, thin to medium bedded bioclastic packstones of facies 4 are exposed in this section. The dolomite occurs in shaly weathering wisps and laminae and in burrow fills. Abundant "*Girvanella*" algal oncolites (algal accretionary grains) are present in beds approximately 4 meters from the base of the section. Rounded dark calcite grains (abraded gastropod fragments) form the cores of

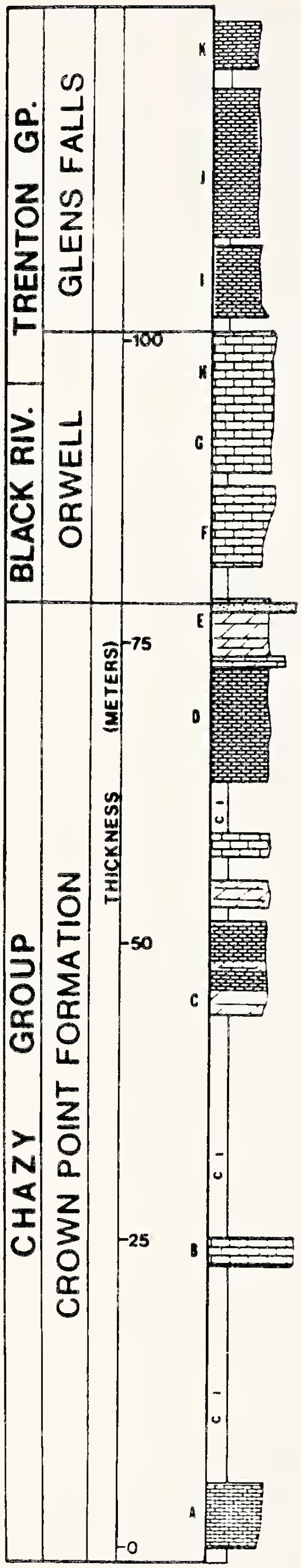


Figure 4 **Composite columnar section of the Crown Point exposures, letters refer to localities at Stop 1 and in field trip description.**

the oncolites and are scattered in other beds. Fossils are relatively abundant and best seen on bedding surfaces. Trilobite fragments, brachiopods, bryozoans, pelmatozoan plates, nautiloids and large *Maclurites magnus* are present. The relatively high faunal diversity, abundant lime mud and burrowing point to a normal marine, low energy, shallow subtidal, carbonate environment. A possible modern analogue is found in the mixed mud and sand shelf to the west of the emergent Andros Island tidal flats described by Bathurst (1971) and Purdy (1963). The 5-10 cm thick beds of "oncolite conglomerate" and other more well-sorted grainstone beds may represent periods of storm winnowing of the bottom, with transportation of abraded sand from adjacent sand shoal environments (e.g. Locality 1B). The wavy, irregular dolomite laminae appear to result from post-depositional dolomitization of lime mud, followed by compaction and local pressure solution of calcite that produced irregular, clay- and dolomite-rich stylocumulate seams. Preferential dolomitization of burrows may be due to contrasts in porosity or permeability of burrow-fill versus burrow-matrix sediment. The burrow-fill sediment may have retained permeability longer during diagenesis and allowed pervasive dolomitization. This sort of fabric-selective dolomitization is common throughout the Chazy and Black River Groups in the southern Lake Champlain Valley.

STOP 1B Ledge immediately northeast of gate to Historic Site.

Cross-stratified coarse lime grainstones (facies 4), some with bipolar crossbed dip directions, are well-exposed near the entrance road. Angular quartz and feldspar grains up to 2 mm in diameter are locally concentrated along prominent stylolite seams. The carbonate particles are dominately subrounded, abraded pelmatozoan plates with gastropod and brachiopod fragments. Large *Maclurites* fragments and grainstone intraclasts are present on the upper bedding plane surfaces of the ledge.

We envision the environment of deposition of this facies as shallow subtidal wave and/or current reworked sand bars. Active transport of abraded grains may have been accomplished by tidal currents as suggested by the bipolar cross-beds or by storm generated currents that produced complex, anastomosing patterns of cross stratification and reactivation surfaces. The lack of burrows and well-preserved fossils may be due to the inhospitable shifting sand substrate. This environment may have resembled unstable sand shoal environments of the Bahamas Platform (Bathurst, 1971; Ball, 1967). The scale and style of cross-stratification present here are similar to that predicted by Ball from his studies of the bedforms and primary structures of the Bahamian sand bodies. Similar Chazyan facies in the northern Champlain Valley contain abundant oolites (Oxley and Kay, 1959).

STOP 1C Low ledges on entrance road approximately 50 meters north of STOP 1B.

Brown weathering, slightly shaley dolostone exposed here contains small lenses and stringers of fossiliferous lime packstone. As at Stop 1A, trilobites, small brachiopods and *Maclurites* fragments are common; however, these fossils are generally better preserved and less fragmentary. This exposure resembles the shelf lagoon facies of Stop 1A although dolomitization is more pervasive and may reflect the more intense bioturbation.

STOP 1D East point of British Fort, by horizontal water tank and adjacent south moat.

Approximately 3 meters of thickly laminated limestone and dolostone (facies 5) are exposed in the southeast "moat" of the British Fort. The dominant facies here consists of alternating 0.5-2 cm thick laminae of limestone and dolostone – often termed a "ribbon rock." The limestone ribbons are mudstones and appear blue-grey on slightly weathered surfaces and as indentations on highly weathered surfaces. The more resistant dolostone weathers tan to brown. An erosional surface with 10-20 cm of relief is exposed near the base of the southwall. Abundant *Maclurites* shells occur in a shell bed on this surface. Lateral accretion cross-strata consisting of gently dipping ribbon rock are present above the erosional surface. Dolomitized burrows transect the limestone ribbons in the lower meter of the section. On the less-weathered prominence on the SE corner of the moat, shallow scours containing a shell hash of brachiopods and gastropod debris are present along with intraclasts of lime mudstone in dolostone and "Mexican Hat" structure (rolled intraclasts or pseudoclasts with a dolomitized burrow center).

We interpret this sequence as a tidal flat to shallow subtidal lagoon facies. The alternating limestone/dolostone "ribbon" fabric may represent rhythms of slightly finer (lime mudstone) and coarser (dolostone) "tidal bedding" similar to that described by Reineck and Singh (1980) from the clastic mud/sand tidal flats of the North Sea. The *Maclurites* shell bed may mark the basal erosional level of a tidal channel with the cross-stratified ribbon laminites formed by draping on the channelled surface. Variations in degree of burrowing record subtle differences in duration of subaerial exposure of the flat and/or extent of reworking by tidal currents. Limited *in situ* faunal diversity is also expected in the stressed tidal flat environments. The absence of mudcracks and any indication of evaporite minerals suggests that only the lower portion of a wet intertidal flat system is preserved here. An alternative explanation is that the "ribbon beds" are storm couplets representing storm beds (=cross-stratified limestones) and quiet-water (=bioturbated dolostones) deposition.

STOP 1E Barracks' localities.

Enter Parade Grounds by barracks. Around 1916, gunite was sprayed on the interior walls to protect the mortar from deteriorating. Starting in 1976, the New York State Division for Historic Preservation began extensive maintenance, removing loose gunite, replacing rotted stones and repainting the stone walls.

In the outer wall of the first barracks, note at about eye level the stones that are nearly white-weathering. These are lime mudstones from the "Lowville" facies of the Orwell Limestone, exposed at Stop 1F.

The broad limestone outcrop west of the barracks is a cross-stratified lime grainstone with scattered subrounded quartz and feldspar sand grains. Trough cross-strata and "herringbone" co-sets of planar-tabular cross-strata are visible on the low vertical face. Large angular clasts of slightly dolomitic lime grainstones and *Maclurites magnus* shells are present on the uppermost bedding surfaces. We interpret this facies as a current-dominated sand shoal environment rather similar to the exposures at Stop 1B.

Westward across the parade grounds there is a massive, bioturbated, brown weathering dolostone unit (similar to Stop 1C), overlain by 0.5 meters of very coarse-grained bioturbated, slightly dolomitic feldspathic quartz sandstone. This sandstone forms the summit of the Chazy Group (Crown Point Formation). The abundant angular quartz and feldspar granules in the sandstone suggest derivation from a relatively close granitic (Adirondack?) source terrane. These sands were apparently transported from the west during an interval of relative emergence of the carbonate platform and were briefly reworked in a shallow marine setting. The basal dolostone bed of the Black River is exposed immediately atop the sandstone.

STOP 1F Moat walls at north entrance to British Fort.

The section from here to locality I is within the Orwell Limestone. The basal beds consist of thick-bedded to massive lime mudstones with vertical spar-filled burrows (ichnogenus *Phytopsis*), fenestral fabric and rare ostracodes. Fossil abundance and diversity increase in the overlying beds, with gastropods (*Loxoplocus*), corals (*Lambeophyllum*, *Foerstephyllum*) and brachiopods appearing. Grain size increases upsection, with sporadic appearance of intraclast grainstones and ripple cross-lamination. Overall, this section is similar to the Lowville Limestone of the type Black River Group of the Tug Hill region. The facies pattern here suggests a progression from restricted (tidal or lagoonal?) mud flats (*Phy-*

topsis lime mudstones) to more open marine mixed mud/sand shelf environments.

The summit of the moat outcrop exposes a horizon of black chert nodules which can be traced laterally across the road to locality G.

STOP 1G Ledges extending from service road to lake shore. Watch for poison ivy!

These exposures resemble the Chaumont (House Creek Limestone of Fisher, 1977) facies of the Black River type section. Thick to massive, richly fossiliferous lime pack- and wackestones document a normal marine, relatively low energy carbonate shelf environment. In addition to the forms mentioned earlier, *Foerstephyllum* and large stromatoporoids (*Stromatocerium*) which are locally overturned and lensing deposits of high-spired gastropods (*Hormotoma* and *Subulites*), the nautiloids *Actinoceras* and *Geisonoceras*, plus bryozoans, trilobites, brachiopods and pelmatozoans are common. On some bedding surfaces, black chert nodules follow large horizontal burrows. The chertification here is postdepositional and involved dissolution and reprecipitation of siliceous skeletal material (sponge and radiolarian). The uppermost bed in this set of ledges is a black chert approximately 2 cms thick. This bed can be traced to the lake shore where a similar section can be seen. Glacial abrasion obscures much of the detail that is exposed on more weathered surfaces.

STOP 1H Blocks and quarry walls by lake shore.

The quarry was established in 1870 by the Fletcher Marble Co. in an unsuccessful attempt to find a source of "black marble" dimension stone. The quarry is reportedly only one meter or so deep. The narrow spit going north was built to load blocks on barges, but evidently no blocks were shipped. The quarried blocks consist of medium to thick-bedded fossiliferous packstones and wackestones with some ripple cross-laminated grainstone beds visible in the north quarry bench. Strophomenid brachiopods, bryozoans, pelmatozoan stems and fragments of the trilobite *Isotelus* are present. The environments represented here are similar to those at 1G. As we continue north and walk along the lake shore, more exposures of the upper part of the Orwell can be examined. The bedding surfaces contain abundant opercula of *Maclurites logani*, and scattered *Foerstephyllum*, *Lambeophyllum* and *Stromatocerium* are found. The byssate bivalve *Ambonychia* is also present.

The transition from the Orwell to overlying Glens Falls Limestone is covered by beach gravels as we continue west along the lake shore.

STOPS 1I,J,K Series of exposures of Glens Falls Limestone separated by beach gravels.

The westernmost outcrops are on *Private Property*, beyond Locality K. Do not go onto that part of the shore (marked by fence and stone wall, plus the large dead elm tree).

The Glens Falls limestone consists of medium to thin-bedded lime packstones and wackestones with some well-laminated, fine-grained bioclastic grainstones. Many limestone beds show internal grading from coarse, fossil-rich bases to less fossiliferous, fine-grained tops. Thin shaley interbeds separate the limestone beds. Horizontal trails and burrows (including *Chondrites*) are common on some bedding surfaces.

Fossils are abundant and rather diverse. Trilobites (usually fragmental) include *Isotelus*, *Flexicalymene* and rare *Cryptolithus*; the brachiopods *Sowerbyella*, *Rafinesquina*; *Dinorthis* and *Dalmanella*; bryozoans *Prasopora*, *Eridotrypa* and *Stictopora*; plus orthocone cephalopods and pelmatozoan debris. Gastropods, which are so abundant in the underlying Orwell limestone are exceedingly rare in the Glens Falls.

The environment of deposition for the Glens Falls was a sub-wave base shelf. No shallow-water features are observed and the graded limestone beds were either deposited by density/turbidity or storm-generated currents. The Glens Falls here records the continuing deepening of the Middle Ordovician shelf that began with the deposition of the *Phytopsis* lime mudstones at Stop 1F. The shale interbeds and generally more argillaceous character of the Glens Falls document increase in terrigenous mud input, perhaps derived from the rising Taconic Orogenic complex to the east. Quartz and feldspar grains of volcanic origin are also common in insoluble residues of Glens Falls limestones, suggesting increased eruptive activity at this time.

The contrast in terrigenous content of the Chazy Group vs. Black River and Trenton Groups is noteworthy. Insoluble residues from Chazy Group carbonates contain abundant, coarse-grained, rather angular quartz and feldspar grains (e.g., Stops 1B and 1D) plus clay-size material whereas the Black River and Trenton Groups lack coarse sand-size grains and contain either volcanic quartz and feldspar (Black River and Trenton Groups) or clay plus volcanics (Trenton Group). This change is likely related to a shift in available clastic source from the slightly emergent cratonic basement to the west that was exposed during Chazy Group deposition to the rising Taconic volcanic/metamorphic complex to the east during Black River-Trenton deposition.

Tectonic Significance of the Crown Point Section

Combining the environments of deposition with the time-thickness pattern of sedimentation, the Crown Point section takes on tectonic meaning. The Chazy sediments were deposited just about at sea level (as suggested by *Girvanella* and *Maclurites*). The Orwell was deposited in shallow sub-tidal conditions (two corals, the grazing snail *Maclurites*, and probably *Stromatocerium*). The Glens Falls was deposited in a more offshore setting.

A time-thickness graph for the Cambrian-Ordovician sequence of the Champlain Lowlands shows some interesting changes in slope. Sedimentation through the Chazy yields a concave-upward curve that shows a continued slowing of crustal subsidence. Then, starting with the Orwell, the crustal subsidence is greater than the rate of sedimentation, because the water deepens. Using the Middle Ordovician time scale of Churkin and others (1977), it is clear that Chazy sedimentation was scarcely 5m/my; the Orwell and Glens Falls accumulated at 30 or 40 m/my, and the thick shales accumulated at 200 m/my (solid-grain thickness). This high rate is comparable to the rate of subsidence of the Australian platform entering the Timor trench (600 m/my; Baldwin, 1982).

The Crown Point section, then, fits the picture of a cooling and slowly subsiding continental margin, through Chazy time. Then, the margin began collapsing as it began to enter a subduction zone to the east, causing water to deepen rapidly. The section is a record of the very early part of the Taconic Orogeny, as the "east-moving proto-North American Plate 'felt' the presence of an approaching island arc" (Baldwin, 1982), a collision that constitutes the Taconic orogeny.

STOP 2 Isle La Motte.

Stop 2 concentrates on strata spanning the Providence Island Dolostone-Day Point Formation contact through the upper Fleury Member of the Day Point Formation. The primary goal is to contrast Chazy Group strata of the northern Lake Champlain Valley with those seen at Stop 1. In addition, we will examine the well-developed boundstone facies characteristic of the Fleury Member of the Chazy Group.

To reach Stop 2 from Stop 1, cross the Champlain bridge from the Crown Point Reservation Site and continue east to Vermont on Route 17. Proceed east approximately 8 miles to Route 22A; turn north on Route 22A and continue to Vergennes, Vermont. Proceed north on Route 22A through Vergennes to Route 7; turn north on Route 7. Continue north on Route 7 to South Burlington, Vermont. Turn east on Route 189, bypassing downtown Burlington to Route 89 north. Proceed north on Route 89 to exit 17, exiting to the Theodore Roosevelt Highway, west (Vermont Route 2). Cross the Sand Bar Bridge on Route 2 to South Hero Island. Continue on Route 2 through Grand Isle, North Hero and Alberg, then proceed west on Route 129 across the island. Continue on Route 129, crossing the La Motte Passage onto Isle La Motte and proceed south (see Figure 5). Continue south past the town of Isle La Motte for approximately 3 miles until the road terminates, bear right, following the road to the south and then sharply west. Turn south into a small clearing and park. Proceed by foot on the path to "The Head". We will walk to the base of the section and then proceed upsection through the Head, Scott, Wait, and Fleury members of the Day Point Formation.

STOP 2A The Head, Isle La Motte, Vermont.

Approximately 3 meters of the Providence Island Dolostone are exposed along the southern shore of the island in the vicinity of Stop 2A. Erwin (1957) reported a total of 21 meters of Providence Island at cliff exposures to the southeast of this stop. The Providence Island strata at this stop consist of yellow-orange to buff weathering dolostones with dessication cracks, LLH stromatolites and beds of intraformational conglomerate. Conglomerate beds are particularly notable in the upper portions of the section. In addition, bioclastic material is present in associated dolomitic lime wackestones. These beds are coarsely transitional with the clastic-rich units typical of the basal Head Member of the Day Point Formation. Although Fisher (1968) dismissed the Providence Island as unfossiliferous, fossil remains include an as yet undescribed trilobite fauna containing elements not present in the *Bolbocephalus-Isoteloides* beds of the underlying Fort Cassin Formation, nor in the diverse assemblages recognized by Shaw (1968) in the Chazy Group. Work is in progress describing the micro- and macrofauna of these beds.

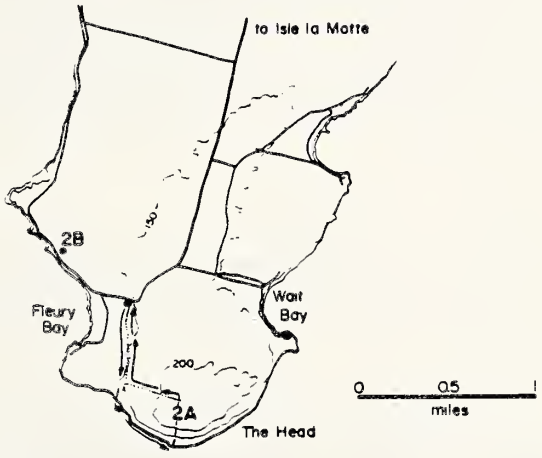


Figure 5 **Location map for localities at Stop 2 (Isle La Motte, Vermont). Open dots designate parking areas and arrows indicate direction of stop log. Stop 2A=The Head (Providence Island Dolostone, basal sandstones of the Day Point Formation (The Head, Scott and Wait Members). Stop 2B=Fisk Quarry (biostromes and small bioherms of the upper (Fleury) member of the Day Point Formation.**

Large scale tabular crossbeds characterize the basal sand-rich units of the Day Point Formation (Head Member). Lithologies range from massive sandstone through more bioclastic, but thinner beds of calcareous sandstones, with interbedded shales and sandy lime mudstone. Fossils, though abundant, are restricted in diversity compared to the succeeding members of the Day Point. *Lingula* and a variety of trace fossils are dominant in the basal beds. Ostracodes, brachiopods and trilobite remains become more abundant as we proceed upsection. This is Shaw's (1968) locality R 18.

The Scott Member of the Day Point Formation crops out as a flaggy-bedded sandy limestone in the first of several benches to the north of the lake shore. The Scott is 5-7 meters thick at this locality, and is characterized by the abundant brachiopod *Mimella vulgaris*, which commonly forms shell pavements. The contact with the overlying Wait Member, dominately a quartz sandstone, is transitional at this locality. The Wait is 3-5 meters thick here (Shaw, 1968; Finks, Shaw and Toomey, 1972).

The lower portion (ca. 35 m) of the Fleury Member of the Day Point Formation is exposed at the top of The Head section in the topmost outcrop bench. Shaw (1968) notes that the bulk of his Day Point collections came from the Fleury. The lower Fleury is characterized by a well-developed cross-bedded oolitic grainstone facies, with thin quartz sandstone and shale interbeds.

Lichenaria heroensis occurs in biostromal lenses and isolated "microherms" within the lower Fleury. Fossils are abundant, and quite diverse, including brachiopods (*Plectorthis exfoliata*, *Clitambonites*, *Camerella*, *Rafinesquina*), trepostome bryozoan fragments, ostracodes, trilobites, pelmatozoan columnals, and the corals *Lichenaria* and *Stictopora*. The corals and bryozoans are most abundant in the coarser grainstone-dominated units.

STOP 2B Fish Quarry.

Return to cars and proceed west and then north approximately 1 mile to large, partially water-filled quarry. Be careful as you walk around the periphery of the quarry.

The upper portion of the Fleury Member of the Day Point are exposed here. Modest stromatoporoid-sponge bioherms (1-2 meters in height, 1-2 meters width in vertical section) stand out in white relief against the dark entombing bioclastic and oolitic grainstones and rudstones. These biohermal facies are absent in apparently coeval strata in the southern Lake Champlain sections, perhaps due to more restricted circulation and more inboard shelf position to the south. Note that the bioherms occur at roughly the same horizon around the quarry face and display a uniform southwest-facing asymmetry in cross-section. This asymmetry likely reflects a growth pattern in response to persistent offshore winds. The abundant disarticulated pelmatozoan remains (blastoid?), sponges, stromatoporoids, corals and bryozoans attest to the great diversity in fixed epifauna and suggests environmental conditions favoring abundant vagrant benthos. The pleurotomarid gastropod *Maclurites* and varied orthoconic cephalopods are locally abundant. Shaw (1968) lists *Sphaerexochus* and *Bumastoides aplatus* as present, but not particularly abundant, at this level.

Collecting is encouraged, but please limit sampling to talus and rubble in the northwest part of the quarry. We would very much like to retain the high quality of the bedding surfaces and walls for future demonstrations.

Regional Significance of the Isle Le Motte Section

Although Kay (1958) and Oxley and Kay (1959) asserted the existence of a significant discontinuity between the Providence Island Dolostone and the overlying Chazy Group, Erwin (1957) indicates generally conformable stratigraphy across the boundary, a view supported by Shaw (1968). Speyer (1982) suggested that the so-called Whiterock unconformity lies between the Fort Cassin Formation and the Providence Island Dolostone on Providence Island in northern Lake Champlain. This may indicate that the magnitude of the unconformity is greater in the southern Lake Champlain region. It is suggested that the name Bridport Dolostone be retained for reference to dolostone beds atop the Fort Cassin in the southern Lake Champlain region and that Providence Island be applied to beds above the Fort Cassin Formation, but beneath the Chazy Group in the northern lake region. Further, it is suggested that Fort Cassin strata in the north, on Providence Island, are approximately time-equivalent to the Bridport Dolostone in the southern lake region; the Whiterock unconformity thereby serving as an approximate isochron. Uplift of the shelf apparently proceeded from the south and west to the north, eventually ending deposition of Fort Cassin strata. The Providence Island Dolostone lies above the Whiterock unconformity in the northern lake region and was deposited immediately prior to earliest Chazy Group deposition. Thus the faunas of the Providence Island may yield important insights into Whiterock deposition and the incursion of Chazyan forms across northeastern migration routes.

The abundant terrigenous clastic influx which marks the beginning of Chazy Group deposition in the northern Lake Champlain Valley indicates uplift of source areas to the present west and north. Terrigenous input to the Chazy shelf gradually decreased through deposition of the Day Point Formation. As a result, organisms prohibited by earlier clastic sedimentation were able to thrive, setting the stage for the initiation and growth of impressive bioherms in the upper Day Point and overlying Crown Point and Valcour Formation.

The contact of the uppermost Chazy strata with overlying basal Black River Group beds is well-exposed near Chazy, New York, approximately 10 kilometers west of Isle La Motte. This contact appears to be gradational both lithologically and faunally (Fisher, 1968; Raring, 1972), quite in contrast to the abrupt facies and faunal changes exhibited at the Crown Point, New York exposure. This may indicate that Chazy Group deposition persisted for a somewhat longer time in the northern lake region, perhaps related to more persistent subsidence of the continental margin along the southern flank of the Quebec Reentrant.

TRIP POST-SCRIPT

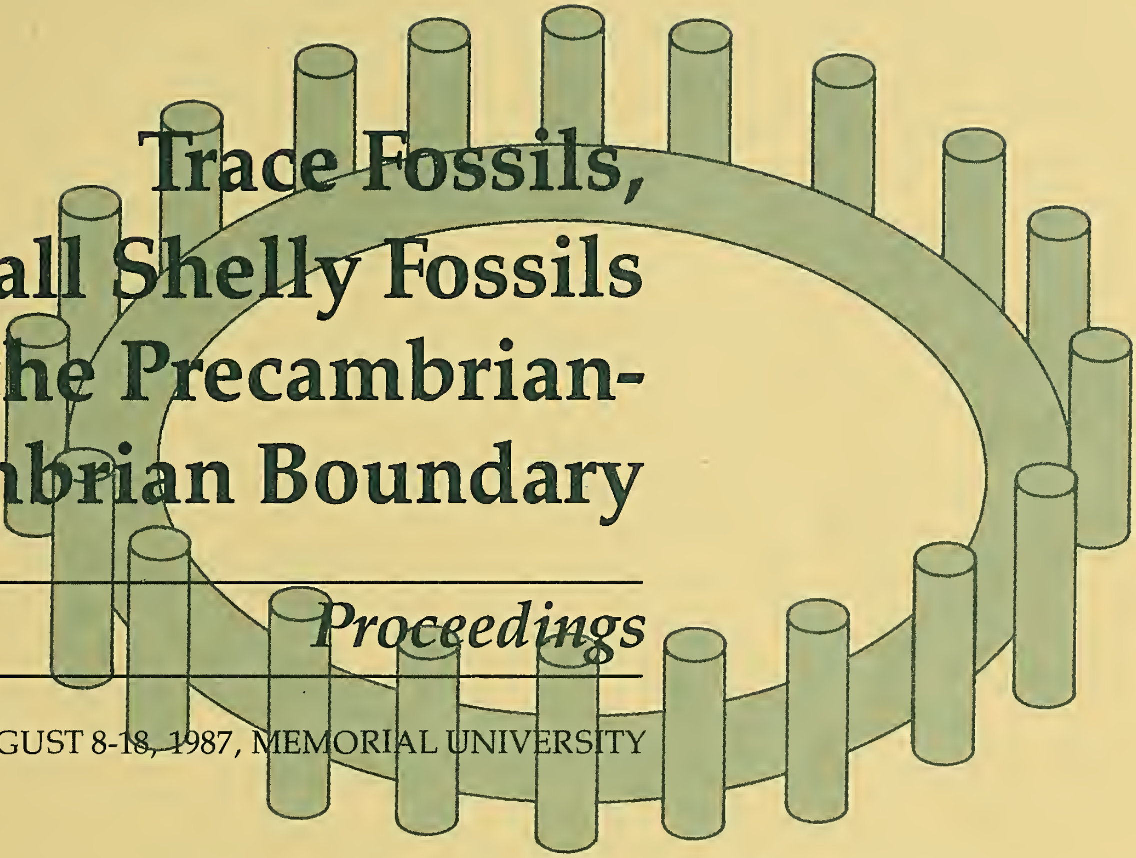
1. Event stratification (in particular, storm-related deposition) was commonly observed at many of the field trip stops. Storm-related deposition was noted at Stop 1A (oncolite conglomerates overlain by fragmental fossil deposits), Stops 1J and 1K (convex-up brachiopod shell pavements and articulated trilobite carcasses overlain by barren lime mudstones reflecting storm accumulation and burial followed by settle-out of fine sediments from turbid water), and at Stop 2A (anastomosing cross-stratification patterns in coarse carbonate grainstones).
2. Several individuals objected to the traditional inclusion of the mature quartz arenite at Stop 1E in the top of the Chazy and preferred to view it as a basal bed of the Orwell. This quartz arenite may mark an important offlap-onlap event between the Chazy and Black River groups in the central Lake Champlain Valley.
3. Although the 2 cm-thick chert bed at Stops 1G and 1H has traditionally been used to mark the contact between the Orwell and Glens Falls limestones, the massive limestones and associated faunas (with *Stromatocerium*, *Foerstephyllum* and *Maclurites*) of the lower part of the "Glens Falls Limestone" are clearly Orwell-like. The thin- to medium-bedded limestones in the upper portions of the Glens Falls Limestone at Stops 1J and 1K are more representative of the Trenton Group and contain a typical "Trenton" fauna (with the trilobites *Ceraurus*, *Flexicalymene* and *Isotelus* and the bryozoan *Prasopora*). The group consensus on the field trip was to regard the lower, massive portion of the "Glens Falls" as Orwell Limestone.
4. Several observations were made on Chazy and Orwell trace fossils. Cross-cutting relationships of trace fossils in the upper Orwell (Stop 1G) indicate a predictable succession of burrowing organisms that produced *Planolites* (first), *Thalassinoides* (second), and *Chondrites* (third). This sequence probably indicates improved oxygenation with time of bottom sediments. Chertification is confined to the 1.0-1.5 cm-wide *Thalassinoides* burrows.

Excellent specimens of *Rusophycus* are present in the basal Head Member of the Chazy Group at Stop 2A. These traces are 10-12 cm in width, are locally superimposed, and may have been produced by *Isotelus*.

NEW YORK STATE EDUCATION DEPARTMENT
ALBANY, NEW YORK 12234

ISSN 0278-33
ISBN 1-55557

1
82X
H



Trace Fossils, Small Shelly Fossils and the Precambrian-Cambrian Boundary

Proceedings

AUGUST 8-18, 1987, MEMORIAL UNIVERSITY

Phycodes coronatum
—a complex burrow representative of the evolutionary modernization of marine animals at the beginning of the Cambrian Period, enlarged

Ed Landing, Guy M. Narbonne, and Paul Myrow, Editors

Bulletin Number 463

NEW YORK
THE STATE OF LEARNING

The University of the State of New York
New York State Museum / Geological Survey
The State Education Department
Albany 12230

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of The University

Martin C. Barell, *Chancellor,* B.A., I.A., LL.B.	Muttontown
R. Carlos Carballada, *Vice Chancellor,* B.S.	Rochester
Willard A. Genrich, LL.B.	Buffalo
Emlyn I. Griffith, A.B., J.D.	Rome
Jorge L. Batista, B.A., J.D.	Bronx
Laura Bradley Chodos, B.A., M.A.	Vischer Ferry
Louise P. Matteoni, B.A., M.A., Ph.D.	Bayside
J. Edward Meyer, B.A., LL.B.	Chappaqua
Floyd S. Linton, A.B., M.A., M.P.A.	Miller Place
Mimi Levin Lieber, B.A., M.A.	Manhattan
Shirley C. Brown, B.A., M.A., Ph.D.	Albany
Norma Gluck, B.A., M.S.W.	Manhattan
James W. McCabe, Sr., A.B., M.A.	Johnson City
Adelaide L. Sanford, B.A., M.A., P.D.	Hollis
Walter Cooper, B.A., Ph.D.	Rochester
Gerald J. Lustig, B.A., M.D.	Staten Island

President of The University and Commissioner of Education
Thomas Sobol

Executive Deputy Commissioner of Education
Robert J. Maurer

Deputy Commissioner for Cultural Education
Carole F. Huxley

Assistant Commissioner for State Museum
Martin E. Sullivan

Director, Division of Research and Collections
Paul J. Scudiere

State Geologist and Chief Scientist, Geological Survey
Robert H. Fakundiny

The State Education Department does not discriminate on the basis of age, color, religion, creed, disability, marital status, veteran status, national origin, race, or sex in the educational programs and activities which it operates. Inquiries concerning this policy of equal opportunity and affirmative action should be referred to the Department's Affirmative Action Officer, Education Building, Albany, NY 12234. Phone (518) 474-1265.

CONTENTS

Page

Introduction

Trace Fossils, Small Shelly Fossils and the Precambrian-Cambrian Boundary: A Pre-Meeting Viewpoint
Ed Landing 1

Dedication

George Frederic Matthew (1837-1923)
Randall F. Miller 4

Abstracts

(Alphabetized by author) 8

Field Trip

Faunas and Depositional Environments of the upper Precambrian through Lower Cambrian, southeastern Newfoundland
Ed Landing, Guy M. Narbonne, Paul Myrow, Alison P. Benus, and Michael M. Anderson 18

Contributed Papers

Radiometric Dating of the Precambrian-Cambrian Boundary in the Avalon Zone
S. Conway Morris 53

Stratigraphy of the Bonavista Group, southeastern Newfoundland: Growth Faults and the Distribution of the sub-trilobitic Lower Cambrian
Ed Landing and Alison P. Benus. 59

Trace Fossil Biostratigraphy in the Precambrian-Cambrian Boundary Interval
Guy M. Narbonne and Paul Myrow 72

Appendix
Bibliography of George F. Matthew
Ed Landing and Randall F. Miller 77

Meeting Acknowledgments 81

Contributors 81

INTRODUCTION

TRACE FOSSILS, SMALL SHELLY FOSSILS AND THE PRECAMBRIAN-CAMBRIAN BOUNDARY: A PRE-MEETING VIEWPOINT

Ed Landing

New York State Geological Survey,
The State Education Department, Albany

GENERAL

The Precambrian-Cambrian boundary interval corresponds to one of the most significant revolutions in the history of life on earth. By comparison with the late Precambrian, the early portion of the Cambrian Period featured relatively modern marine faunas and communities. Although abundant remains of multicellular animals occur in some late Precambrian sequences, these include relatively large, soft-bodied forms that lacked the mineralized internal and external skeletons that are present in many Cambrian and younger marine animals. In addition, other late Precambrian animals differed from Cambrian forms in that they rarely had the ability to burrow deeply into sediments or graze the surface of sediments in complex feeding patterns that allow an efficient use of food resources.

An amateur or professional natural historian would recognize many similarities with modern marine faunas and communities in Early Cambrian seas, whether in eastern New York State, elsewhere in North America, or on other continents. Snails and other mollusks, tube-dwelling "worms," and biologically constructed reefs with nooks and cavities occupied by a host of smaller organisms were all present. However, a large number of relatively short-lived animal groups also appeared in the Early Cambrian evolutionary radiation. These "problematica," such as tommotiids and coelosclerotophorans, may prove to have only distant relationships to existing marine animals. A few other groups, such as hyolithids and orthothecids, persisted into younger strata but are really most abundant in and a key component of Early Cambrian communities. Trilobites appeared only later in the Early Cambrian and presumably occupied some of the ecologic niches occupied by modern crustaceans.

The 1970s and 1980s featured an international renaissance in research on Early Cambrian faunas. This is approximately a century after a number of energetic works [e.g. S.W. Ford of Troy, New York; C.D. Walcott, United States Geological Survey; G.F. Matthew and E. Billings of Canada; H. Hicks, C. Lapworth, and A. Sedgwick of Great Britain; Fr. Schmidt in Estonia; and W.C. Brögger, J.G.D. Linnarsson, and J.C. Moberg in Scandinavia] emphasized the use of these fossils for interregional time correlation. The formation of the Precambrian-Cambrian Boundary Working Group has served since the early 1970s to encourage work on boundary interval faunas and stratigraphy. The early and continuing efforts of Soviet scientists are now complemented by those of workers in a number of other countries.

"TRACE FOSSILS, SMALL SHELLY FOSSILS AND THE PRECAMBRIAN-CAMBRIAN BOUNDARY"

A data base that is appropriate for evaluating the resolution of faunal-based relative time correlation is being developed with the description of more boundary sections and more complete documentation of the stratigraphic and geographic ranges of small shelly fossils and trace fossils. Just as a hundred years ago, this meeting, "Trace Fossils, Small Shelly Fossils, and the Precambrian-Cambrian Boundary," will emphasize traditional biostratigraphic practices, such as reliance on the lowest horizon of species' occurrences and empirically-derived ancestor-descendent relationships, in attempts at more highly resolved correlations. Although this is appropriate as a first attempt at establishing a local biostratigraphy, the coordinators hope that this meeting will transcend an "onion skin biostratigraphy" that is based solely on the comparison of stratigraphic ranges of fossils between widely separated sections.

Statements that casually assert that sections represent "continuous deposition" through a critical interval or that "lineage zones" establish a precise time relationship between sections must be severely questioned during this meeting. P.M. Sadler's work on the expected but extraordinary incompleteness of sedimentary rock sequences and N. Eldridge's demonstration that a descendent species may immigrate into its ancestor's range as much as a geological age after its evolution must be kept in mind. Indeed, the abrupt appearance of a new fauna in a section should be accepted as *prima facie* evidence either of unconformity or of the geologically instantaneous transition to different environmental regimes during onlap or offlap.

Paleontologists interested in Precambrian-Cambrian boundary faunal successions must complement the traditional stratigraphic range charts of fossil occurrences with thorough documentation, photographic illustration, and environmental interpretation of those portions of stratigraphic successions that record abrupt faunal changes. Short- to long-term hiatuses at cryptic unconformities or the possibility of extreme sedimentary condensation must be evaluated at such transitions. In addition, paleontologists should remember that "Walther's Law," the lateral equivalency of facies in a continuous vertical section, is appropriate not only to lithostratigraphy but also to the communities that track environments and facies during onlap and offlap. A number of reference sections through the boundary interval have a lower conoidal fossil and *Protohertzina* assemblage and an overlying, more diverse, hyolith- and mollusk-bearing assemblage. The available data in the literature is often amenable to interpretation as evidence either for unconformity or for a record of two onlap sequences in which the higher fauna could be the more open-marine equivalent of the lower.

In addition to problems arising from stratigraphic incompleteness and intra-regional differences in litho- and biofacies, taxonomic practices also affect the resolution of Precambrian-Cambrian boundary biostratigraphy. A discouraging trend has developed in the taxonomy of small shelly fossils. Although many of these remains have few unique morphologic features, are subject to post-mortem alteration in depositional and diagenetic environments, and are certain to have had considerable ontogenetic variation, more and more new "species" are being named on the basis of such subjective features as size, proportions, curvature, or strength of ornament. In addition, a single poorly focused photograph of a single specimen is often the only illustration available to the scientific community.

The lower-level taxonomy of small shelly fossils is too frequently reminiscent of the typophiletic orientation that characterized a number of paleontologists in the 1940s and 1950s. Associations of morphologically distinct types of sclerites into multielement skeletons are frequently not recognized and each sclerite type receives its own Linnean designation. In addition, numerous species of animals that bore one skeletal unit are often distinguished from single samples on the basis of minor morphologic differences. These differences are often nearly noncommunicable in text descriptions and are poorly illustratable. Even though fossil assemblages are time-averaged accumulations, the suggestion from modern habitats is that niches are sufficiently broad that the ranges of few species of a genus can be expected to overlap in a habitat. A concomitant development, particularly in treatments of hyolithids, orthothecids, and other tubular fossils, is the naming of more tightly defined genera that individually include fewer species (e.g. Landing, *In Press*).

As more questionably defined, lower level taxa are created by regional workers, it obviously becomes easier to propose "evolutionary" lineage zonations based on the vertical succession of "species" in individual sections. This practice may be particularly acceptable to phyletic gradualists in their development of finely subdivided chronostratigraphic sequences. Hopefully, time and the motivation are available to document intrahabitat species' variability in small shelly fossils and to evaluate ecophenotypic and taphonomically-controlled variation within species' environmental ranges before a boundary stratotype is selected.

The utility of a small shelly fossil-based biostratigraphic signature for definition of the Precambrian-Cambrian boundary at a stratotype candidate must be evaluated at this meeting. Although a number of horizons have been proposed at other candidate stratotypes, these correspond to stratigraphically abrupt first-appearances of faunas. Despite claims that an "evolutionary event" is recorded, stratigraphic continuity is questionable at these sections. Interregional correlation of such assemblages cannot give precise correlations because the oldest portions of the stratigraphic ranges of the assemblages are probably not locally preserved. This situation certainly compounds an agnostic's reservation about the potential time resolution of zonal correlation even between stratigraphically complete sections. The *caveat* is that although multi-species assemblages can be used to establish relatively precise intraregional time correlations, the base of a faunal zone is commonly defined by the lowest occurrence of one or two species. These lowest occurrences must be somewhat diachronous even between stratigraphically complete sections because of the time-lag between a species' evolution and its emigration to other areas of its potential range. Immigration history and potential unconformities are factors that may preclude the precise correlation of the bases of a number of small shelly fossil zones.

These factors are compounded in interregional correlation by the strong faunal provincialism that was present in the boundary interval. Preliminary paleomagnetic information and the presence of younger Caledonian and Hercynian sutures within many continents suggest a relatively large number of plates and continents in the earliest Cambrian. Restrictions on dispersal across the oceans between these continents led to the development of well defined faunal provinces or, perhaps more appropriately, faunal "realms." The well-documented, diachronous, first local occurrences of archaeocyathans and trilobites on separate Early Cambrian continents are only two examples of the existence of biogeographic regions with distinct evolutionary histories. Despite this, a number of small shelly fossils were essentially cosmopolitan in the earliest Cambrian. However, these geographically widespread species appear to have had extremely long, stage-magnitude ranges, and their lowest occurrence should not be relied upon for interregional correlation of boundary interval strata. (Landing, *In press*).

The proposal at this meeting to define a Precambrian-Cambrian boundary stratotype in the Chapel Island Formation at the lowest occurrence of a Cambrian-aspect trace fossil assemblage (Narbonne *et al.*, 1987) is a response to perceived inadequacies [provincialism, facies control, documentation from unconformity-bounded and condensed sequences, long stratigraphic ranges, taxonomic inconsistencies] in the biostratigraphic utility of small shelly faunas. This change in trace fossil composition is very near the lowest occurrence of metazoan-secreted, organic-walled tubes (*Sabellidites cambriensis*) in the section, a situation which also seems to be true for the East European Platform and Siberia (see abstract by Fedonkin). The use of the base of the *Phycodes pedum* Zone in the Chapel Island Formation as an interregionally correlatable boundary "signature" results in the assignment of almost all presumed latest Precambrian and earliest Cambrian small shelly faunas in other regions to the earliest Cambrian. This proposal represents the first attempt to establish the base of a geological system (and the bases of its lowest series and stage) at the base of a trace fossil, rather than a body fossil, zone. The assignment of the base of the *Phycodes pedum* Zone to the base of the Cambrian has the consequence of referring most of the Chapel Island Formation and the overlying sub-trilobitic strata of the Random Formation and Bonavista Group to the Lower Cambrian. This interval has a composite thickness of ca. 1.4 km and is more than an order of magnitude thicker than other approximately coeval sections in the carbonate facies of Siberia and southern China. The relative completeness of this stratigraphic sequence is certainly better developed than in other boundary interval successions.

Activity by the Precambrian-Cambrian Boundary Working Group was formally begun in 1972. Although the duration of this project has certainly been much longer than originally anticipated, the consequences of deferring the designation of a stratotype section and horizon have been beneficial. Far more information is available on boundary interval stratigraphic history, earliest Cambrian faunal replacements and evolutionary radiations, and faunal provincialism than at earlier meetings during which boundary selection was attempted. The eventual selection of a boundary stratotype and horizon will allow further investigation of interregional correlation within the Cambrian and determination of the geographic extent of series- and stage-level subdivisions of the Cambrian.

The awareness of a sub-trilobite portion of the Lower Cambrian has reached the broader geologic community as a result of research that was ultimately prompted by the Precambrian-Cambrian Boundary Working Group. However, one unfortunate result of this has been a tendency in recent reports to refer subtrilobitic intervals in North America, among other areas, to the "Tommotian Stage" even though the archaeocyathans and diagnostic small shelly faunas of that stage are not locally represented. A unified chronostratigraphic subdivision of the Lower Cambrian that is appropriate to a number of continents may not be possible.

The concept of chronostratigraphic units differs from that of a biostratigraphic unit; however, the definition of a chronostatigraphic unit relies on the empirical evidence provided by conventional biostratigraphic practice. The base of a stage in its type area obviously corresponds to the base of a faunal zone and the series consists of the rocks of a number of successive stages. Stages and series originally defined in one magnafacies of a biotic realm are often less clearly defined or are simply not recognizable in coeval, adjacent, but strongly dissimilar magnafacies. Lateral facies changes across the shelf-slope break in North American Ordovician sequences, as one example, are so severe that the same stage- and series-level units cannot be applied in these two facies belts. Similarly, rocks and faunas that are coeval to those of such British intervals as the Tremadocian Series or Cautleyian Stage exist in North American Ordovician sequences, but realm-level differences in faunas mean that the very material basis (e.g. the faunas) for recognizing these chronostratigraphic units is not well developed in North America. Insular series- and stage-level subdivisions of the Lower and higher portions of the Cambrian appear to be appropriate in a number of distinct biogeographic regions and would serve to distinguish the unique evolutionary and immigration histories and to reflect the paleogeographic setting of these areas (e.g. Landing *et al.*, 1987).

ACKNOWLEDGMENTS

"Trace fossils, Small Shelly Fossils, and the Precambrian-Cambrian Boundary" is a meeting which came about only through the assistance of many individuals and organizations. These are gratefully acknowledged at the end of this volume. Grants from the Royal Ontario Museum, the National Geographic Society (grants 2453-82 and 2619-83) and the National Science Foundation (EAR83-12939) made possible the author's field and laboratory program on Lower Cambrian paleontology. W.H. Fritz, M. A. S. McMenamin, and G. S. Nowlan are thanked for providing a review of this contribution.

REFERENCES CITED

Landing, E. In press. Lower Cambrian of eastern Massachusetts: Stratigraphy and small shelly fossils. Jour. Paleontology.

_________, Narbonne, G.M., Benus, A.P., and Myrow, P. 1987. Etcheminian – Lowest Cambrian Series in Avalon. Geol. Soc. Amer. Abst. Prog. 19:24.

Narbonne, G.M., Myrow, P., Landing, E., and Anderson, M.M. 1987. A stratotype candidate for the Precambrian-Cambrian boundary, Burin Peninsula, southeastern Newfoundland. Canadian Jour. Earth Sci. 24:1277-1293.

DEDICATION

George Frederic Matthew (1837 – 1923)

Randall F. Miller
New Brunswick Museum
Saint John

INTRODUCTION

Work was regarded as man's moral duty in Victorian society. Idleness was perceived as a lack of discipline, and the study of natural history offered some individuals a means to fill every moment with useful activity. A knowledge of natural history was part of the intellectual equipment of many educated people. It was associated with wealth and religion, with self- and social improvement, and was regarded as 'rational amusement' (Berger, 1983). In this atmosphere, George Frederic Matthew became the ideal amateur naturalist and geologist. Although he maintained his position as a customs clerk, he became internationally known for his studies in paleontology. In many ways, Matthew represented the ideal of the Victorian naturalist more than his colleagues because he retained an amateur position through his whole life. Dawson, Bailey, Hartt and others were able to develop their scientific interests into a professional career while Matthew, by choice or circumstance, did not.

This Bulletin is dedicated to George F. Matthew for his early recognition of a sub-trilobitic interval in the Lower Cambrian of Maritime Canada. Matthew designated this as the "Etcheminian Series" and provided succinct descriptions of the small shelly fossils that allowed correlation of this interval on the Avalon Platform. Although Charles Doolittle Walcott prevailed in his dismissal of the "Etcheminian" and included it as part of his Lower Cambrian "*Olenellus* Zone" or "Waucoban Series," a number of areas where the "Etcheminian" was originally recognized have provided a standard of reference for correlation of the lowest Cambrian. The "Etcheminian" rocks of New Brunswick and southeastern Newfoundland are an integral part of the Precambrian-Cambrian boundary problem and provide insights into the earliest Cambrian evolutionary radiation of the Phanerozoic fauna. The 1987 meeting of the Precambrian-Cambrian Boundary Working Group in St. John's, Newfoundland, featured a proposal to define the boundary stratotype in a section near the City of Fortune, Newfoundland, that Matthew would have included in his Etcheminian.

MATTHEW'S LIFE AND INTEREST IN GEOLOGY

George Frederic Matthew was born on August 12, 1837, in Saint John, New Brunswick, at a time when the city was a busy port and an important cultural center in eastern North America. His father was a merchant in the city. At that time, an education in New Brunswick was a matter of privilege and cost $6 – $8 per quarter (Schuyler, 1984). However Matthew's family was able to send him to St. John Grammar School in south Saint John near his home. The school, a small one-story building, was operated by the Trinity Anglican Church. Matthew's formal education ended after grammar school, and at the age of fifteen, he entered public service in the Saint John Custom House.

His position in the customs house was to last most of his life, and he eventually became Chief Clerk and Surveyor. Matthew's public service apparently warranted further recognition which never came to him. L.W. Bailey, Matthew's friend and colleague, believed that "had it not been for political consideration in which he (Matthew) played no part, there can be little doubt that he would have been made Collector of the Port, a position which it was generally felt should have been offered to him" (Bailey, 1923, p. viii). Matthew's position in the public service did, however, have rewards as it must have allowed him some time and the financial means to pursue his interests in geology. In addition, he was able as a customs clerk to meet travellers from around the world, an experience that contributed to the growth of his collections. Although Matthew did not attend university to study geology, the intellectual atmosphere in Saint John certainly served to support his keen interest in natural history. In addition, its complicated geologic setting provided ample challenges for his scientific curiosity.

At the age of twenty, Matthew expressed his interest in geology and paleontology by assisting in 1857 in organization of the Steinhammer Club. The club's purpose was to learn about the local geological formations (Squires, 1945), an interest which had been catalyzed by the exhibition of Abraham Gesner's geological collection in 'Gesner's Museum' in Saint John between 1842 and 1846.

Matthew undertook the study of New Brunswick geology at an opportune time. William (later Sir William) Dawson had just published the first edition (1855) of "Acadian Geology" which dealt mostly with Nova Scotia. The revised second edition, which included new information on New Brunswick, would be published in the next decade. The Geological Survey of Canada was enduring a second decade of financial insecurity. However, Confederation in 1867 would increase the Survey's operation tenfold. Sir William Logan, director of the Survey, met with Professor H. How and D. Honeyman of Nova Scotia, Dr. L.W. Bailey of New Brunswick and George Matthew in Portland, Maine, in 1868 to discuss the extension of the Survey's work into the Maritime Provinces. As temporary employees of the Survey, Matthew, Bailey, How and Honeyman were each to be paid $500 annually (Zaslow, 1975). The geological mapping of New Brunswick was about to begin on a grand scale.

Bailey, a student of Louis Agassiz while at Harvard, taught science at King's College (now part of the University of New

Brunswick) and was one of Matthew's first colleagues and longest friends. Bailey's mapping in the 1860s was done with the field assistance of George Matthew and Frederick Hartt, and it was, in fact, Matthew who sparked Bailey's interest in the geology of New Brunswick. Between 1864 and 1881, Bailey, Matthew and R.W. Ells published at least a dozen reports and maps on geology of New Brunswick.

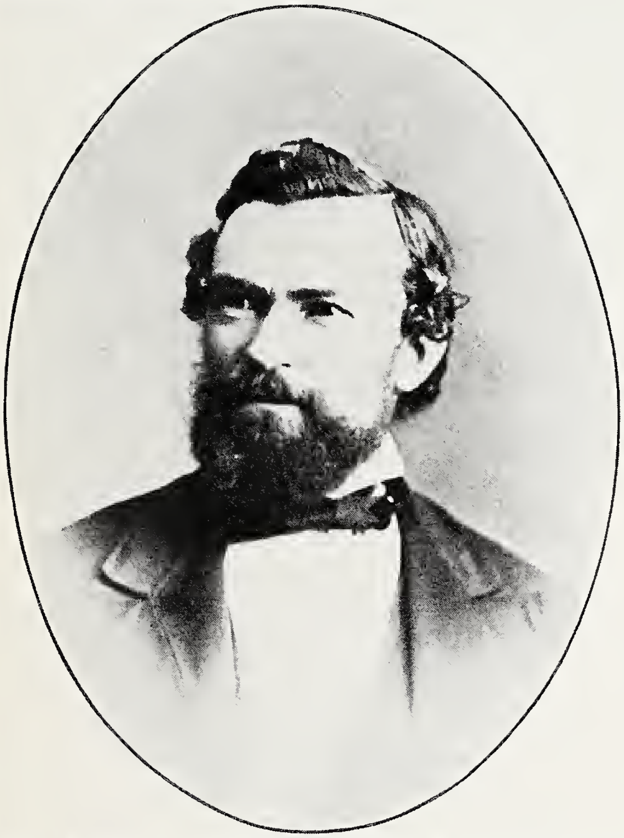


Figure 1. Formal portrait of George Frederic Matthew from Geological Survey of Canada archives, courtesy of A.D. McCracken.

MATTHEW'S WORK AND THE NATURAL HISTORY SOCIETY

Dawson's interest in the activities of the Steinhammer Club was due, in part, to Hartt and Matthew. They provided information and specimens that Dawson used in his revision of "Acadian Geology" (Dawson, 1868) and in earlier reports on the Carboniferous and Devonian floras of New Brunswick. Dawson was Canada's foremost geologist, had worked with Robert Jameson, Charles Lyell and William Logan, and likely exerted considerable influence on Matthew and on the level of activity of the Steinhammer Club. At Dawson's suggestion, a Natural History Society was established in Saint John in 1862. George Matthew became a charter member and the Society's first curator.

The Natural History Society met at the Mechanic's Institute until 1868 when a new room was found for collections and meetings in the basement of Matthew's old grammar school (Matthew, 1912). The room provided unsuitable and the collection was returned to the Mechanic's Institute six years later. The move proved fortunate as the school was destroyed in the Great Saint John Fire of 1877. The Fire left most of south Saint John in ruins and destroyed the customs house and Matthew's home.

Among Matthew's losses were part of his library and half of his recently discovered specimen of the giant trilobite *Paradoxides regina*. According to Bailey (Saint John Globe, April 21, 1923), the specimen had already survived an earlier fire at the customs house and was in Matthew's home when it was damaged. The publication of its description did not appear until ten years later, no doubt a consequence of the fire which slowed the pace of leisure activity in Saint John for a number of years. The Natural History Society remained dormant for several years after the fire, but Matthew continued to publish and produced reports for the Geological Survey of Canada. He continued working as a temporary paleontologist for the Survey until 1901. He occasionally recovered his expenses and supplemented his Customs House salary through his geological work or the sale of specimens. Letters from G.M. Dawson, Director of the Survey, indicate that financial arrangements were made for Matthew's work in Newfoundland and Cape Breton (NBM Archives):

> From G.M. Dawson, June 11, 1898
> "...it is a little difficult to pledge even the sum of $50.00 in connection with your proposed expedition to Newfoundland, except as you propose in the way of payment for specimens...Mr. Whiteaves is quite anxious to have specimens of the kind, but he would like if possible to ensure that those we should get be the first set of duplicates, in order that they might possess a value somewhat in accord with Billing's type or co-types of Newfoundland things, which we already have."

In a reply on November 9, 1898, Dawson confirmed the receipt of samples and authorized payment to Matthew.

> From G.M. Dawson, May 23, 1900
> "...In the case of Dr. Adams and Prof. Bailey ...they require for working up and preparation of one report one additional month, making in all at a rate of $125 per month the sum of $500. It may be ....that the amount of subsequent work you require to do is greater ....."

Renewed activity took place in Saint John after the Fire and grand new buildings replaced those that were destroyed. The Natural History Society was reinvigorated and began to publish the "Bulletin of the Natural History Society of New Brunswick" in 1882. Matthew paid for the printing of the second number at his own expense. In the same year, the Royal Society of Canada began to meet in Ottawa. Dawson selected the first men to represent the geological and biological sciences and invited Matthew, Selwyn, Bell, Whiteaves, Bailey, Laflamme, Macoun and Hoffmann to become charter members (Zaslow, 1975). In 1889, Matthew became President of the Natural History Society of New Brunswick and, three years later, was elected President of the Geological and Biological Section of the Royal Society. Matthew quickly took advantage of new outlets for his work and began to publish regularly in the Natural History Society and Royal Society journals. He published more than 200 papers and corresponded with geologists in Canada, the United States, Britain and continental Europe. Some of his papers were translated into Russian, Belgian, Swedish and

Japanese. Matthew's own command of Swedish was so thorough that he was asked to provide translations for the United States government. His first paper, published in 1863, filled nineteen pages in the Canadian Naturalist and Geologist and reported on the geology of St. John County where he would continue to do much of his work.

His papers were often descriptive accounts of new species; however, he did write essays in an attempt to synthesize the regional geology and biostratigraphy of those areas where he worked. His interests spanned the full range of geology from Quaternary climate and archeology to Precambrian paleontology. Although he lived at a time when religion strongly influenced the beliefs of geologists, he did not mention it in his writings, as others, such as Dawson often did, nor did he discuss the influence of Darwin. It was said that "he did not labor like Sir William Dawson to reconcile Geology and Genesis" (Lucian, *in* Saint John Globe, May 12, 1923). Principles of evolution were rarely discussed in natural history societies in Canada, except in Montreal where Dawson influenced the debate (Berger, 1983). Matthew's friend Bailey seemed "outwardly untroubled by the controversy" surrounding Darwinism (Berger, 1983, p. 69-79; Bailey, 1925) and we might assume that Matthew held similar views.

By the early 1890's, George Matthew was well established as a member of the geoscience community in Canada and, unlike his peers, still worked as an amateur. However a "Who's Who" of the time (Morgan, 1898) listed him as a geologist. Laval University awarded him a doctorate of science in 1894, and the University of New Brunswick bestowed an honorary doctorate in 1897. A few years before he died, Matthew received the Murchison Medal from the Royal Geographical Society of London.

The varied geology of Saint John has long provided a focus for research. Within a few miles of Matthew's home were Precambrian rocks from which he described one of the first known stromatolites, *Archaeozoon acadiense*. A short distance away, Cambrian-Ordovician rocks contained an array of invertebrates that he described while plants, insects and trackways at the "Fern Ledges" also occupied his energies. The topic that led to Matthew's criticism by the scientific community was his belief that the plant beds at the "Fern Ledges" were of Devonian age. Matthew's conclusions were contrary to the evidence presented by paleobotanists. The basis of Matthew's arguments was that the stratigraphy necessitated a Devonian age and that the fossil interpretations were in need of revision. This thesis was related to Matthew's early work as a stratigrapher and his faith in the conclusions of his friends Dawson and Bailey on the age of these rocks. Even after Marie Stopes reexamined the "Fern Ledges" and published her memoir (Stopes, 1914), Matthew still seemed to question a Carboniferous age. In his eighties, Matthew was so determined to prove an older age that he walked the Bay of Fundy coastline westward to Maine to relate his observations to those made by United States' geologists (Bailey, 1923). At the time of his death, he was preparing a paper to defend his original views.

Collections from British Columbia, Cape Breton Island and Newfoundland were sent for his examination, and his interest in the Cambrian led him away from New Brunswick for brief periods. Matthew spent part of the summer of 1898 near Smith Sound in Newfoundland, and his longest single work, a "Report on the Cambrian Rocks of Cape Breton," was prepared between 1899 and 1903 at the request of G.M. Dawson, Director of the Geological Survey of Canada.

Matthew devoted a great deal of time to his science, not only through research but also by his involvement with the Natural History Society. He found time to devote to his studies even though his customs house duties kept him occupied and poor eyesight forced him to use a secretary at times (L.W. Bailey, *in* Saint John Globe, April 21, 1923). In his first year as the Society's president, he also served on standing committees for geology, the library, essays and lectures, publications, the meeting hall and the press. This was not an unusual commitment for him. Matthew continually enriched the Society's collection through exchanges and gifts and from his own collection. His wife was a president and active member of the Ladies' Association of the Society. Katherine Mary and George Matthew raised six sons and two daughters. Their son William was also a member of the society and accompanied his father in the field on many occasions. William Matthew, who later became a curator of vertebrate paleontology at the American Museum of Natural History, was less than seven years old when he discovered the specimen of *Paradoxides regina* that was later damaged in the Great Saint John Fire.

COLLECTIONS

George F. Matthew's collections were divided up after his death and are now reposited in several locations. As a member of the Natural History Society of New Brunswick, Matthew donated parts of his collection to the Society. These collections are now part of the New Brunswick Museum. Also included in the NBM collection are specimens from Matthew's Cambrian studies which were sent to Professor B.F. Howell at Princeton University by Matthew's wife and son William after his death. They considered the specimens would be best cared for by someone working on the Cambrian of New Brunswick (NBM Archives). This collection was acquired by the New Brunswick Museum in 1986.

Before Matthew's death, Sir William MacKenzie provided money to the University of Toronto to purchase Matthew's private collection from his estate. The collection, which includes many of Matthew's types, is at the Royal Ontario Museum.

Matthew's collections received much attention while he was working, and he actively exchanged samples with colleagues in North America and Britain. Many specimens, particularly some of the reptile or amphibian trackways that he studied, are stored in the Redpath Museum. Collections were also sent to the Geological Survey of Canada as a condition of the work he conducted for the Survey. Other specimens are in the collections of L.W. Bailey at the University of New Brunswick and one collection has been located at the Sedgwick Museum. One newspaper article following his death stated that Matthew contributed to more than fifty museums (Lucian, *in* Saint John Globe, May 12, 1923).

Matthew described more than 350 new species of invertebrates, plants, ichnofossils and fish. Not all of the type specimens have been located. Although some of his work has been revised or questioned, much of it remains valid and attests to his excellence as a scientist with a keen sense of observation and an untiring spirit. George Matthew died of pneumonia at the age of 86 in Hastings-on-Hudson, New York, at his son William's home. When he passed away he was still working on papers on the geology of southern New Brunswick.

ACKNOWLEDGMENTS

I would like to thank Ed Landing for asking me to write this dedication to George Frederic Matthew and for his helpful editing and added comments on Matthew's study of "Etcheminian" fossils. Thanks are also due D.F. McAlpine and S.R. Clayden for reviewing the manuscript and C. Rosevear and D. Lemon of the New Brunswick Museum Library and Archives for their assistance in locating letters and documents. A special thanks is extended to Margaret and Dr. Edwin H. Colbert for wonderful discussions concerning Margaret's grandfather, George Frederic Matthew.

REFERENCES CITED

Bailey, J.W. 1925. Loring Woart Bailey: The Story of a Man of Science. J. & A. McMillan, Saint John, 141 p.

__________ 1923. George Frederic Matthew. Proc. Trans. Roy. Soc. Canada, 3rd ser., 17(4):vii-x.

Berger, C. 1983. Science, God, and Nature in Victorian Canada. University of Toronto Press, Toronto, 92 p.

Dawson, J.W. 1868. Acadian Geology. MacMillan, London, 694 p., (2nd edition).

Matthew, G.F. 1912. Sketch of the Natural History Society of New Brunswick. Bull. Nat. Hist. Soc. New Brunswick, 30:457-474.

Morgan, H.J. 1898. Canadian Men and Women of the Time: A Handbook of Canadian Biography. William Briggs, Toronto. 1118 p. (1st ed.).

Schuyler, G. 1984. Saint John: 200 Years Proud. Windsor Pub. (Canada), 208 p.

Squires, W.A. 1945. History and Development of the New Brunswick Museum. Administrative Series No. 2, New Brunswick Museum, 42 p.

Stopes, M.C. 1914. The "Fern Ledges" Carboniferous Flora of St. John, New Brunswick. Canada Dept. Mines, Mem. 41, 142p.

Zaslow, M. 1975. Reading the Rocks. The Story of the Geological Survey of Canada 1842-1972. MacMillan, London, 599p.

ABSTRACTS OF PAPERS PRESENTED AT THE PRECAMBRIAN-CAMBRIAN BOUNDARY WORKING GROUP MEETING

Additional information on the oral and poster presentations summarized in these abstracts should be obtained by contacting the authors.

FIRST APPEARANCE OF TRACE FOSSILS IN MACKENZIE MOUNTAINS, NORTHWEST CANADA, IN RELATION TO THE HIGHEST GLACIAL DEPOSITS AND THE LOWEST SMALL SHELLY FOSSILS

AITKEN, James D., Geological Survey of Canada, 3303-33rd St. N.W., Calgary, Alberta, T2L 2A7

In the central Mackenzie Mountains, the terminal Proterozoic succession consists of three upward-shallowing Grand Cycles: Twitya-Keele, Sheepbed-Gametrail, and Blueflower-Risky. Each cycle consists of a sharply-based formation of thick, deep-water mudrocks and turbidites that are gradationally overlain by a formation dominated by carbonate rock.

The Risky carbonate at the top is overlain by a wedge of red and green argillite and sandstone with an upper limestone member, the Ingta Formation. The Ingta carries a rich but nondiagnostic ichnofauna, including some large traces; its limestone member has yielded *Protohertzina* cf. *anabarica*. The Risky, itself tripartite, is correlated here with a thicker, dolomite-siliciclastic-dolomite package reported from the Wernecke Mountains that contains Ediacaran fossils and is in immediate erosional contact with overlying beds bearing small shelly fossils.

The lowest trace fossils in the Mackenzie Mountains (*Gordia* sp., *Torrowangea* sp. and problematica) appear abruptly at the base of the Blueflower (base of third Grand Cycle), and are accompanied by the Ediacaran fossils *Pteridinium* sp., *Inkrylovia* sp., and *Sekwia excentrica*. Lithofacies identical to those bearing the traces occur in each of the preceeding Grand Cycles.

The highest Proterozoic glacial deposits (previously unreported) can be placed firmly in reference to the lowest traces in an apparently conformable sequence. They occur in the middle of the Keele Formation (carbonate cap of first Grand Cycle). Thus, more than a complete Grand Cycle (at least 10 m.y.?) separates the oldest trace fossils from the youngest glacial deposits.

The new formation names are established in Geological Survey of Canada Bulletin 368 (in press).

SKELETAL FOSSILS AT THE PRECAMBRIAN-CAMBRIAN TRANSITION: PALEOBIOLOGICAL AND BIOSTRATIGRAPHIC SIGNIFICANCE

BENGTSON, Stefan, Inst. of Palaeontology, Box 558, S-751 22 Uppsala, Sweden

The skeletal fossils of the Precambrian-Cambrian transition represent biotas of unique importance for our understanding of the history of life. Yet they have hitherto played a very insignificant role in the development of evolutionary paleobiology, and they have also been of limited use for global biostratigraphic correlations. Part of the reason for this is that they have been intensively studied only for a comparatively short time. Their taxonomy, phylogeny, and patterns of occurrence are therefore still very incompletely known.

But it may not be simply a question of obtaining more data of the kind we already have; some of the problems encountered appear to be of a more fundamental nature and are related to the fact that these fossils represent an early major phase of metazoan radiation. The tendency to pigeon-hole the fossils into living phyla has led to many misinterpretations of their biological nature. An important question is whether patterns of variability, both within species and between taxa, differ from what we find in later biotas. Few studies on early skeletal fossils have included variability aspects. Factors of mineralogical composition, taphonomy, and preservation have also tended to be neglected. A better understanding of the taxonomy, phylogeny, and ecology of these organisms could help us analyze the evolutionary processes involved in the origin of higher taxa.

On the basis of recent work on material from China, Australia, and the Siberian Platform, carried out in collaboration with colleagues, a presentation will be given of current research into the biological nature of the early skeletal fossils, as well as of their present and potential usefulness for biostratigraphical correlation.

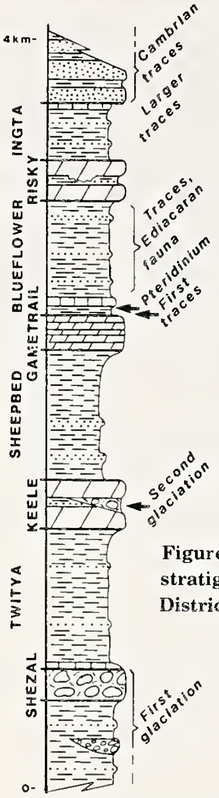


Figure 2. Upper Precambrian – Lower Cambrian stratigraphy, central Mackenzie Mountains, District of Mackenzie, Canada.

SEDIMENTOLOGICAL CONTEXT OF A DEEP-WATER EDIACARAN FAUNA (MISTAKEN POINT FORMATION, AVALON ZONE, EASTERN NEWFOUNDLAND)

BENUS, Alison P., Dept. of Earth Sci., Memorial University, St. John's, Nfld. A1C 3X5

The Mistaken Point Formation (Conception Group) is an important unit in the Avalon Zone of eastern Newfoundland because it hosts a prolific and diverse late Precambrian (Ediacaran) fauna. Softbodied metazoans of the Mistaken Point differ from practically all other known Ediacaran faunas in that they occur in a deep-water marine environment and are apparently mostly endemic. Superb coastal exposures at the type section and at a locality 30 km to the west near St. Shotts have provided a basis for a detailed sedimentological study of the upper part of the ca. 400 m-thick Mistaken Point Formation.

The Mistaken Point Formation is composed of two dominant siliciclastic facies associations: A) interbedded, medium to thick turbidites and thin hemipelagic mudstone layers (sandstone/mudstone ratios greater than 1.0) and B) interbedded, thin to medium turbidites and hemipelagic layers (sandstone/mudstone ratios less than or equal to 1.0). Medium to thick turbidites consist of arkosic arenites (Ta-Td divisions) overlain by structureless mudstones (Te). The local amalgamation of up to four such turbidites produces massive sandstone beds with mudstone rip-up clast horizons. Thin to medium turbidites consist of relatively finer-grained arenites (Ta or Tc, commonly) overlain by structureless mudstones.

Thin (ca. 1-2 cm), hemipelagic mustone layers, interbedded with the turbidites, are characterized by mm-scale, discontinuous laminae. Such layers contain cm-thick volcanic bands as well as fossiliferous bedding surfaces. The preservation of anomalously sharp contacts between the turbiditic mudstones and overlying hemipelagic mudstones was favored by the lack of bioturbation in these late Precambrian deposits.

Although sole-markings are relatively rare in Mistaken Point strata, a southeasterly transport direction is indicated by cross-laminae in the turbidites. The approximate down-slope direction derived from clastic dike orientations is compatible with this southeasterly direction.

Deposition in outer fan, lobe and lobe-fringe environments is suggested by facies associations A and B, respectively, as well as by the sheet-like bedding nature, lack of channels observable on outcrop scale, and lack of the gravity-controlled, wet-sediment deformation often associated with slope settings. This mud-rich, high efficiency fan was adjacent to a volcanic terrane.

Interpreted lobe and lobe-fringe deposits alternate through this upper Precambrian sequence with thinner-bedded lobe-fringe sediments becoming more prevalent upward. The lack of obvious, mesoscale, thickening- and coarsening-upward sequences (commonly interpreted as the result of lobe progradation) or thinning- and fining-upward sequences (lobe abandonment) requires further explanation.

Nine abundantly fossiliferous surfaces were recognized within the 11 m to 68 m interval above the base of the type section. These fossils have been preferentially preserved on bedding planes within hemipelagic layers, below volcanic ashes, and below possible fine-grained, volcanic-rich(?), bottom current deposits. Although turbidity currents were the dominant transport mechanism in this outer fan setting, they probably served to uproot and destroy the fauna. On the other hand, settle-out deposits and sediment laid down by relatively sluggish bottom currents blanketed and preserved the organisms.

Both the lack of size-sorting of Mistaken Point fossils and the presence of animals with attachment discs or surfaces directly overlain by settle-out deposits indicate that the organisms occur more-or-less *in situ*. In addition, delicate specimens, such as the "star-shaped" form (Anderson and Conway Morris, 1982), were not likely transported.

Current measurements were determined using elongate fossils (spindle- and bush-like forms, *Charnia*, and other problematic unnamed forms) on seven bedding surfaces. The dominant northeasterly direction indicated by the assemblages is approximately perpendicular to the transport direction of the turbidites and reflects contour current activity in this environment. Furthermore, similar animals show a comparable distribution of current directions. For example, epibenthic animals with attachment discs have a more uniform orientation than spindle-like forms that may have been bathypelagic or only weakly attached to the bottom.

The preservation of Mistaken Point fossils as external molds that are deeply impressed into the sediment implies that the organisms had a tough leathery integument and a body plan that was more inflated than is generally believed in attempted reconstructions of Ediacaran metazoans. Spindle-like individuals were bent by the currents into broad arcs but are not kinked or doubled over upon themselves. Such animals were, therefore, relatively stiff.

The formation of a fracture cleavage in these rocks has confounded earlier taphonomic interpretations and illustrations of the fauna. This cleavage has taken probable circular structures, such as attachment discs, and transformed them into ellipses with length/width ratios of approximately 2.0. The elongation of the fossils parallel to cleavage and their shortening perpendicular to cleavage was not considered in Anderson and Conway Morris' (1982) calculations of length to width ratios of the soft-bodied metazoans.

Lastly, a 10 cm-thick tuff in the lower part of the type section of the Mistaken Point Formation has yielded a radiometric date of 565 ± 3 myr. This analysis, carried out by G. Dunning of the Royal Ontario Museum, was based on U-Pb determinations on zircons. The approximate 565 myr date is significantly younger than proposed ages for the Newfoundland fauna as reported in the literature. For example, Anderson (1972) estimated an age of 610-630 myr which he revised to "at least 680 m. yr" (Anderson, 1978, p. 147; Anderson and Conway Morris, 1982). This latter age is, in part, based on comparison of the Conception Group with the lithologically similar, Vendian fossil bearing, Charnian Supergroup of Leicestershire, England. Other workers (Brückner et al., 1977) believe that the soft-bodied fauna of Newfoundland is still older, on the order of 1,000 myr. However, all of these older dates, as well as estimates of the beginning of the Cambrian that propose a 560-600 myr age, must be re-evaluated.

'INNER TETHYAN' PRECAMBRIAN-CAMBRIAN BOUNDARY SEQUENCES FROM CHINA, INDIA, PAKISTAN AND IRAN

BRASIER, Martin D., Dept. of Geol., University of Hull, U.K.; HAMDI, B., Geol. Survey of Iran, Tehran; and JIANG Zhiwen, Yunnan Inst. of Geol. Sci., Kumning, Yunnan, China

New evidence indicates that a belt of rocks bearing a similar succession of boundary events extends from Meishucun in eastern Yunnan and Maidiping in southern Sichuan, southern China, through the Indian Lesser Himalaya to northern Pakistan, the Oman and northern Iran. This 'Inner Tethyan Belt' has many accessible reference sections which are now being researched through international collaboration. The boundary interval sequences of the Inner Tethyan belt can be divided into five biostratigraphically defined zones.

Zone O events include 1) grand cycle top of dolomite unit (e.g., Donglangtan Member), the latter associated with first *Hyolithellus* and a mollusk in northern Iran; 2) epibole of *Chuaria* group and vendotaeniid algal group macroflora as seen on the Yangtze Platform and in northern Iran; and 3) first appearance datum (=FAD) of *Protohertzina anabarica* group, *Anabarites trisulcatus* and *Cambrotubulus decurvatus* as seen in northern Iran. This may correlate with strata bearing *Sinotubulites* in the Dengying Formation, Hubei.

Zone I assemblages are traceable across the Yangtze Platform to the Lesser Himalaya and northern Iran. These faunas usually appear near the top of widespread dolomites and range through commercial grade phosphate-clastics. Events include: 1) FAD of *Cassidina pristinis-Maikhanella multa* group (Marker A of Meishucun, upper Middle Dolomite of northern Iran); '*Circotheca*' '*Conotheca*' group, *Spinulitheca billingsi* group, *Turcutheca crasseocochlia* group, *Tiksitheca licis* group; 2) major phosphogenic cycle with negative del ^{13}C trend that occurs across the Yangtze Platform to the Lesser Himalaya and probably also occurs in Pakistan, Iran and southern Kazakhstan; 3) FAD of *Salanacus* sp. *Barbitositheca ansata*, *Hexangulaconularia formosa* group, *Maldeotaia bandalica-Ganloudina symmetrica* group and hyoliths with rounded triangular cross sections, these assemblages are recognized in Meischucun, northern and southern Sichuan, the Lesser Himalaya and northern Iran; 4) rising del ^{13}C values and shoaling at Meishucun.

Zone II: Coiled, sculptured molluscs of the *Latouchella korobkovi* and/or *Aldanella attleborensis* groups appeared suddenly and widely at Marker B in Meishucun and Maidiping in Sichuan, in the Yangtze Gorges, and, questionably, in northern Iran. This occurrence is in sediments of varying ecological and paleoclimatic setting and perhaps reflects rapid migration. The marker is not yet clear in northern Iran and is unclear in India, northern Sichuan and Guizhou. Zone II events include FAD of this new fauna and shoaling and emergence that culminate in ferruginous crusts or stromatolites which are traceable across the Yangtze Platform and, questionably, into India.

Zone III features a paleogeographic change from condensed calcareous to thicker clastic (often carbonaceous and bioturbated) sedimentation. These developments are seen along the belt from China to Iran. Associated events include 1) Iridum and negative del ^{13}C anomalies in basal black shales on Yangzte Platform, 2) FAD of *Allonnia tripodophora* and *Archiasterella pentactina* at similar levels in Yunnan, Sichuan, the Lesser Himalaya, and northern Pakistan; 3) appearance of diverse traces in Yunnan, Sichuan and Lesser Himalaya.

Zone IV features the appearance of the trilobites *Parabadiella* and *Mianxiandiscus* with the brachiopod *Botsfordia caelata* in Yunnan. International correlation of Zone IV is uncertain. In Zone V, trilobites became significant and widespread during *Eoredlichia* time in China. The *Pelagiella lorenzi* group appeared in Sichuan, the Lesser Himalaya and northern Iran; and *Diandongia pista* is reported from Yunnan, Sichuan and the Lesser Himalaya.

METAZOAN EVOLUTION NEAR THE PRECAMBRIAN-CAMBRIAN BOUNDARY: USE AND MISUSE OF SMALL SHELLY FOSSILS

CONWAY MORRIS, Simon, Dept. of Earth Sci., Univ. of Cambridge, Downing Street, Cambridge CB2 3EQ, U.K.

The abrupt appearance of skeletal hard-parts near the Precambrian-Cambrian boundary is an evolutionary conundrum that has puzzled paleontologists since the time of Darwin. Study of such assemblages has been dominated by Soviet and Chinese research, a natural corollary of the superb exposures of richly fossiliferous Lower Cambrian sediments in both the U.S.S.R. and China. It is perhaps less well known, however, that some of the basic concepts surrounding small shelly fossils were formulated by the Canadian paleontologist G.F. Matthew in the last century during his studies in New Brunswick and Newfoundland. However, the importance of the Avalon Zone in such discussions is only now receiving just recognition.

Despite substantial advances in the study of small shelly fossils, major problems remain in the interpretation of their paleobiology, paleontology and evolutionary history. Those that will receive specific attention include:

a) How is it best to classify small shelly fossils? This question stretches from species-recognition to problems of high-level taxonomy. To date, thousands of species have been erected, but many are of dubious validity. Some are too fragmentary to be identified reliably, others may be preservational variants, while many are the variously shaped sclerites derived from the scleritome of a single species. Not surprisingly, with species recognition and definition in turmoil, discussion of higher-level classification is still in its infancy.

b) What was the mineralogy of early skeletal parts? In these metazoans both calcium carbonate and calcium phosphate were employed, but a consensus has emerged that the latter mineral was of unusual importance in comparison with the rest of the Phanerozoic. However, until primary skeletal phosphate can be distinguished from secondary replacement arising during diagenesis, this hypothesis is questionable. Ultrastructural investigations offer a reliable method of distinction, and present information indicates that secondary phosphatization was usually prevalent. This in turn raises problems of taphonomic interpretation of small shelly fossil assemblages as well as the possible mechanisms of phosphate replacement.

c) What is the stratigraphic potential of small shelly fossils? The problems of correlation in the Lower Cambrian using small shelly fossils are now notorious, and there is a growing realization that certain taxa had lengthy stratigraphic durations that preclude their use for any detailed correlation. However, even when allowance is made for such factors, their use in stratigraphic resolution continues to present major obstacles.

d) What is the biogeography of small shelly fossils? Although faunal similarities between some regions are quite noticeable, in many other cases there appears to be little affinity. If a more reliable Lower Cambrian paleogeography was established, recognition of biogeographic provinces might be placed on a more secure footing.

e) To what extent is metazoan diversification, especially in terms of hardparts, linked to extrinsic physico-chemical factors? Shifts in ^{34}S and ^{13}C, together with major episodes of phosphate deposition, point towards substantial changes in ocean chemistry. Are these perturbations merely coincidental or are there causal links?

These questions will be addressed with particular reference to a continuing study of small shelly fossils from Australia and China, in collaboration with Stefan Bengtson, Bruce Runnegar, Peter Jell, Barry Cooper and Chen Menge. For each question some preliminary answers or suggestions can be given, but the original conundrum is still far from a general solution.

TRACE FOSSILS AND CORRELATION OF LATE PRECAMBRIAN AND EARLY CAMBRIAN STRATA

CRIMES, T. Peter, Dept. of Geol. Sci., University of Liverpool, Liverpool L69 3BX, U.K.

Trace fossils are abundant and diverse in many clastic sequences that span the Precambrian-Cambrian boundary and may prove to be the most useful paleontological method for global correlation at this level.

The ichnofaunas of the latest Precambrian (Vendian) rocks include some forms whose range does not extend in to the Cambrian (e.g. *Bilinichnus*, *Intrites*, *Palaeopascichnus*, *Vendichnus*, *Vimenites*) and others which continue throughout most or all of the Phanerozoic (e.g. *Arenicolites*, *Aulichnites*, *Cochlichnus*, *Didymaulichnus*, *Gordia*, *Neonereites*, *Planolites*, *Skolithos*).

At least 50 ichnogenera make their first appearance below the lowest trilobites in sections with broad geographic extent. A few of these appear to have a short time range and extend to about the lowest occurrence of the trilobites (e.g. *Astropolichnus*, *Didymaulichnus miettensis*, *Plagiogmus*, *Taphrhelminthopsis circularis*), but the majority continue through most or all of the Phanerozoic.

For correlation of Precambrian-Cambrian boundary sequences, it is therefore possible to use both the occurrence of those ichnogenera with a short time range and the incoming of those with an extended range.

Three stratigraphical zones can be recognized with respect to the incoming of trace fossils. Zone I is of late Vendian age and includes *Arenicolites*, *Bilinichnus*, *Cochlichnus*, *Didymaulichnus*, *Gordia*, *Harlaniella*, *Intrites*, *Nenoxites*, *Neonereites*, *Palaeopascichnus*, *Skolithos*, *Vendichnus* and *Vimenites*. In Zone II, of early Tommotian age, the earliest examples of *Bergaueria*, *Phycodes*, *Teichichnus* and *Treptichnus* are encountered. Many trace fossils appear in Zone III, which extends from the upper Tommotian to the lower Atdabanian, but the most important are *Astropolichnus*, *Cruziana*, *Diplichnites*, *Diplocraterion*, *Dimorphichnus*, *Plagiogmus*, *Rusophycus* and *Taphrhelminthopsis circularis*.

This vertical zonation of trace fossils allows an attempt at world-wide correlation from which the most significant conclusions are that the Vendian/Tommotian boundary can probably be placed (i) near the middle of the McNaughton Formation in the Rocky Mountains, Canada; (ii) at the base of the Deep Spring Formation or in the underlying Reed Dolomite in the White-Inyo Mountains, California, U.S.A.; (iii) low in the Chapel Island Formation in the Burin Peninsula, Newfoundland, Canada; (iv) at or close to the base of the Candana Quartzite in northern Spain; (v) at or below the base of the Breivik Member in Finnmark, Norway; and (vi) near or below the base of the Zhongyicun member at Meishucun, China.

The sections in the Burin Peninsula, Newfoundland, and Meishucun, China, are favored candidates for the global stratotype for the Precambrian-Cambrian boundary. In the Burin Peninsula, the trace fossils suggest that the Tommotian/Atdabanian boundary may be within or at the base of the Random Formation, thereby implying that the Tommotian may include a thickness of over 500 m of sediment that comprises at least most of the Chapel Island Formation. At Meishucun, the ichnofaunal evidence implies that the Tommotian/Atdabanian boundary is probably no higher than the top of the Zhongyicun Member. The thickness of the Tommotian is therefore possibly only about 20 m here, implying a very condensed sequence, a conclusion consistent with an abundance of phosphorites. Two stratotype reference points for the Precambrian-Cambrian boundary have been suggested in this section. The lower point (0.8 m above the base of the Xiawaitoushan member) may be near the Vendian/Tommotian boundary or younger, while the higher point (base of Unit 7 of the Zhongyicun member) is probably upper Tommotian or even lower Atdabanian. The higher point would place the boundary above the world wide dramatic increase in trace fossil abundance and diversity but probably before the first trilobites. This would almost certainly have advantages for correlation. The inference that the Meishucun section is younger than most Chinese work suggests should not therefore, by itself, prejudice its adoption as global stratotype.

PRECAMBRIAN-CAMBRIAN BOUNDARY PROBLEM ON THE SIBERIAN PLATFORM

ESAKOVA, N.V., Paleontological Inst. of the U.S.S.R., Academy of Sciences, Moscow 117868

Siberian Platform sections are most suitable for a detailed biostratigraphic subdivision of the Precambrian-Cambrian boundary interval. The best sections for solving these problems are those along the middle Aldan River (the Ulakhan-Sulugar outcrops and the Dvortsy), on the north-west slope of the Anabar Uplift (sections of the Kotuy and Kotuykan Rivers), on the Olenyok Uplift (sections of the Olenyok and Khorbusuonka Rivers), and in the Utchuro-Maya district (the Gonam River section) (Fig. 3).

The Ulakhan-Sulugur section was chosen a stratotype candidate for the Precambrian-Cambrian boundary on the territory of the U.S.S.R. (The Resolutions of the ISC of the USSR, 1982). The boundary is drawn in the upper parts of the Yudoma Formation at the bottom of Bed 8. This is the stratotype of the *Aldanocyathus sunnaginicus* Zone.

In all the sections under consideration, the Lower Cambrian boundary is established by a mass appearance of various skeletal fossils (hyoliths, mollusks, zooproblematica) of the *A. sunnaginicus* Zone. This fauna can be compared with the assemblage of Bed 8 in the statotype.

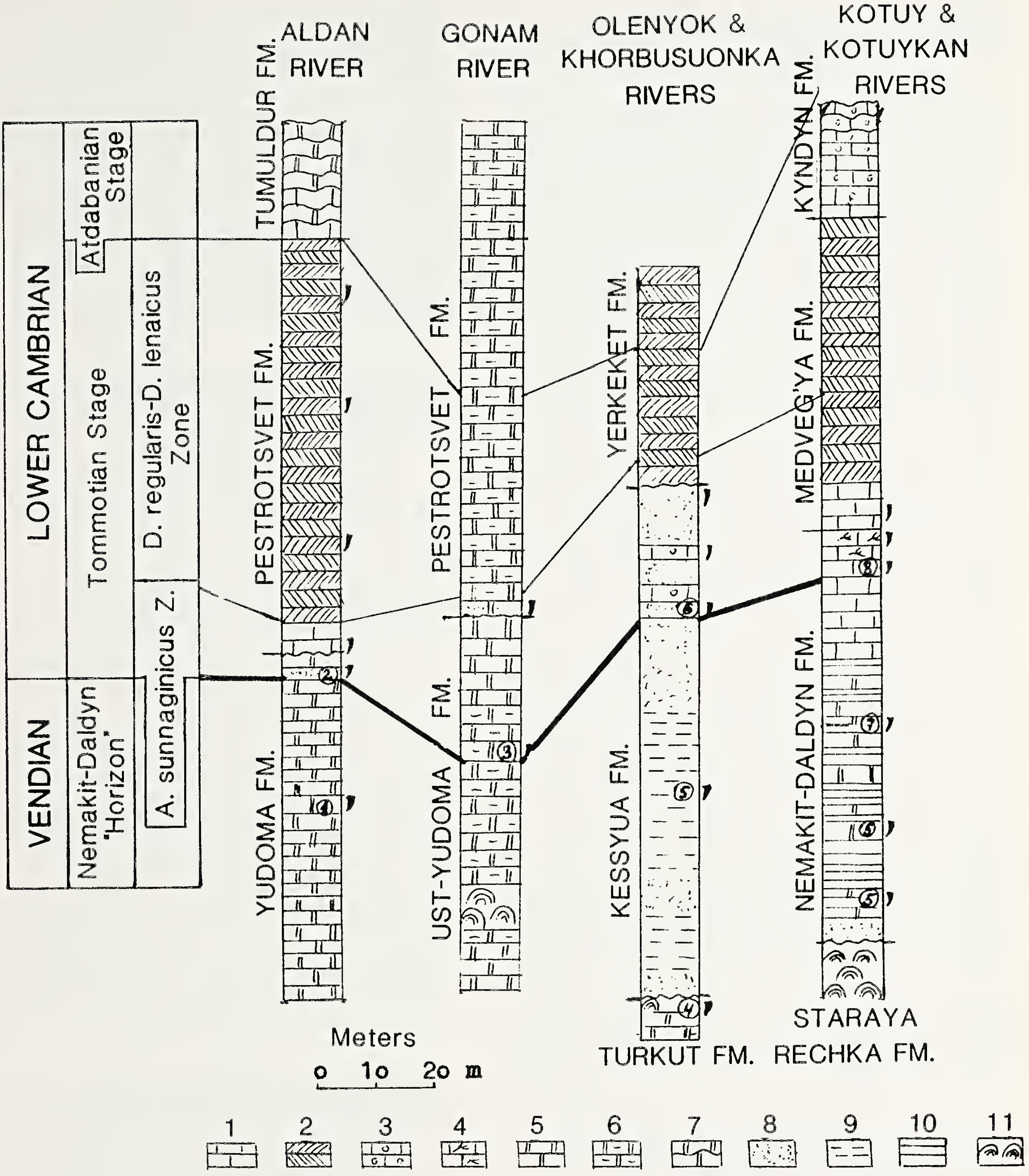
Certain differences in organic remains exist between the most ancient Cambrian beds of the north (the Anabar region) with those to the south (the Utchuro-Maya district). These differences across the Siberian Platform are due to facies control of a number of groups that compose the skeletized faunas.

Problematic skeletal remains (*Anabarites trisulcatus* Miss., *Cambrotubulus decurvatus* Miss., *Protohertzina anabarica* Miss., and others) occur below the lowermost Cambrian in the sections under consideration. There are two altogether different viewpoints on the correlation of the Precambrian-Cambrian boundary interval between the north and south sections. One group of investigators draw the boundary at the base of the *A. sunnaginicus* Zone of the Tommotian Stage while others place it at the base of the *Anabarites trisulcatus* Zone of the Manikayan Stage. The later workers consider the Nemakit-Daldyn Horizon as a part of the Lower Cambrian.

Figure 3. Correlation scheme of Precambrian-Cambrian boundary interval strata on the Siberian Platform. ➤

1-limestone, 2-clayey particoloured limestone, 3-oncolitic limestone, 4-algal limestone, 5-dolostone, 6-clayey dolostone 7-wavy-laminated dolostone, 8-quartz arenite, 9-siltstone, 10-mudstone, 11-stromatolites.

1. ?*Hyolithellus* sp., ?*Chancelloria* sp., *Lobiochrea* sp.;
2. *Spinulitheca kuteinikovi*, *Turcutheca crassecochlia*, *Conotheca* sp., *Laratheca nana*, *Exilitheca multa*, *Bemella jacutica*, *Purella crista*, *P.* cf. *parula*, *Aldanella rozanovi*, *Barskovia* sp., *Hyolithellus tenuis*, *Torellella curva*, *T. lentiformis*, *Cambrotubulus decurvatus*, *Tiksitheca licis*, *Coleoloides trigeminatus*, *Sunnaginia imbricata*, *Sachites sacciformis*, *Marcuelia* sp., *Chancelloria lenaica*;
3. *Ladatheca annae*, *Loculitheca* cf. *anulata*, *Purella* cf. *antigua*, *Igorella* sp., *Barskovia* sp., *Hyolithellus* cf. *tenuis*, *Cambrotubulus decurvatus*, *Fomitchella* cf. *infundibuliformis Marcuelia* cf. *prima*, *Chancelloria* sp.;



4. *Cambrotubulus* sp.;

5. *Anabarites trisulcatus*;

6. *Ladatheca* sp., *Conotheca* sp. *Allatheca concinna, Circotheca obesus Turcutheca crassecochlia, Purella cristata, P. antigua, Barskovia, Salanyella costulata, Heraultipegma* ex gr. *sibirica, Hyolithellus tenuis, Tiksitheca korobovi, Anabarites tripartitus, Anabaritellus hexasulcatus, Sachites sacciformis, Rhabdochites* sp., *Tommotia* sp., *Chancelloria* sp., *Prooneotodus* sp.;

7. *Anabarites trisulcatus, Cambrotubulus decurvatus, Protohertzina anabarica*;

8. *Cambrotubulus decurvatus, Anabarites trisulcatus, Tiksitheca licis T. korobovi, Angustiochrea lata, Hyolithellus tenuis, Torellella* sp., *Sachites* sp.

PALEOICHNOLOGY OF THE PRECAMBRIAN-CAMBRIAN TRANSITION IN THE RUSSIAN PLATFORM AND SIBERIA

FEDONKIN, Mikhail A., Paleontological Inst. of the U.S.S.R., Academy of Sciences, Moscow 117868

Comparative studies of Vendian and Lower Cambrian trace fossils from the Russian Platform (a basin with terrigenous sedimentation) and from the Siberian Platform (basin with carbonate sedimentation) show general regularities in the evolution of ichnocoenoses within the Vendian-Cambrian boundary interval. However, a considerable facial and a possible paleogeographic control of the composition of ichnocoenoses have been discovered.

The Russian Platform features the following sequence (the lowest appearance of ichnofossils is mentioned): 1) The Vendian, the Redkino Horizon: *Aulichnites, Bergaueria, Bilinichnus, Cochlichnus, Gordia, Helminthoida, Intrites, Medvezhichnus, Nenoxites, Neonereites, Vendichnus, Vimenites* and *Yeloviochmus*. These forms are associated with the imprints of soft-bodied animals. The finds of *Asterichnus* and *Stellogliphus* are also significant. 2) The Kotlin Horizion: *Chomatichnus, Circulichnus, Harlaniella, Monocraterion*. 3) The Rovno Horizon: *Bergaueria major, Didymaulichnus, Gyrolithes, Phycodes, Sokolovichnites, Teichichnus, Treptichnus bifurcus, T. triplex*. 4) The Lower Cambrian, the Lontova Horizon: *Diplocraterion, Rhizocorallium, Rusophycus* (rare). 5) The Talsin Horizon: *Cruziana, Dimorphichnus, Diplichnites, Halopoa, Saggitichnus, Skolithos linearis.*

On the Siberian Platform, *Nenoxites, Palaeopascichnus* and meniscoidal feeding burrows have been found in the Vendian (Yudomian) in the interval where a soft-bodied fauna occurs. Primary sedimentary sturctures are sometimes fully destroyed in carbonate rocks by bioturbation. The Nemakit-Daldyn Horizon includes *Bergaueria, Didymaulichnus, Gordia, Olenichnus, Phycodes, Planispiralichnus, Protospiralichnus* in clastic rocks. Higher Lower Cambrian rocks of the Tommotian Stage contain *Didymaulichnus meanderiformis, Diplocraterion* (in terrigenous rocks) and *Rhizocorallium, Chondrites* (in carbonate units).

Both regions are characterized by comparable developments. The lower half of the Vendian has a wide diversity of ichnofossils which reflect mainly peristaltic methods of motion for small animals near the surface of the sediment. Trace fossils of such types as paschchnia and fodinichnia are dominant. Terrigenous shallow-water facies of the lower half of the Vendian (levels of highest abundance of soft bodied metazoan remains) contain more trace fossils than carbonate facies. However, this situation is possibly explained also by taphonomic reasons. A gap in the paleontological record of the Vendian metazoans on the Russian Platform (the Kotlin Horizon) is associated with a decreased taxonomic diversity of ichnofossils. Stromatolite facies are widespread at this level in Siberia. Of great importance is a sudden appearance of trace fossils of Paleozoic type below the base of the Tommotian Stage of the Lower Cambrian.

Athough they are biostratigraphic analogues, the Rovno Horizon and the Nemakit-Daldyn differ considerably in the composition of ichnocoenoses even in similar facies. This may reflect geographic or climatic differences.

At the end of the Vendian and the beginning of the Cambrian, biological processing of sediments increases; the size of trace fossils enlarges, and their symmetry changes. The progressive colonization of sediments by soft-bodied animals and the building of skeletons by other groups of invertebrates can be interpreted as different responses by benthic animals both to the increasing pressure of predators and to increased competition for habitats and nutrition sources in shallow marine environments. The colonization of sediments by soft bodied, infaunal metazoans and by skeletalized epifaunal invertebrates increased the habitat area of the benthos. The building of skeletons was important not only for protection but for forming areas of stable substrate. Skeletalization allowed sedentary forms to develop a habitat that could not be disturbed by bioturbation by the soft-bodied infauna.

ICHNOSTRATIGRAPHY OF SOME CAMBRIAN-ORDOVICIAN ROCKS OF EASTERN NEWFOUNDLAND

FILLION, D., and PICKERILL, R.K., Dept. of Geol. , Univ. of New Brunswick, Fredericton, N.B. E3B 5A3

Unfossiliferous or poorly fossiliferous sedimentary sequences potentially can be dated and correlated by detailed examination of trace fossils. This approach has been widely applied to many Cambrian-Ordovician sequences in England, Wales, southwest Europe, and the Mediterranean region. The trilobite-produced ichnospecies of *Rusophycus* and *Cruziana* have been the most useful trace fossils in biostratigraphy. However, the ichnostratigraphic paradigm developed in Europe has not been successfully applied to any coeval succession in North America until the present.

The Cambrian Ordovician sequence (Bell Island and Wabana groups) on Bell Island, Conception Bay, eastern Newfoundland, consists of shallow, subtidal siliciclastics with a diverse, abundant, and well-preserved trace fossil assemblage. Spectacularly preserved, trilobite-produced trace fossils, including *Cruziana* (walking tracks), *Dimorphichnus* (sideways grazing traces) and *Monomorphichnus* (swimming-grazing traces), are present in this assemblage. Detailed examination of the distribution of *Cruziana* species within the sequence have enabled a more accurate definition of the Tremadocian-Arenigian and lower-upper Tremadocian boundaries than previous paleontological studies have permitted. The former boundary is based on the final occurrence of *C. semiplicata*, which is an Upper Cambrian-Tremadocian species, and the latter is based on the initial occurrence of *C. furcifera* and *C. goldfussi*. These latter species have been reported previously from upper Tremadocian and higher strata. It is suggested that the Tremadocian-Arenigian boundary be placed at the 1,200 m level and the lower-upper Tremadocian boundary at 1,020 m in the sequence.

TRACE FOSSIL BIOSTRATIGRAPHY IN PRECAMBRIAN-EARLY CAMBRIAN SEQUENCES, NORTHWEST HIMALAYA, INDIA

KUMAR, G., Geological Survey of India, BV 11, H Road, Mahanagar Extension, Lucknow 226 006

The late Precambrian-Early Cambrian sequences of the northwest Himalaya, India, have yielded abundant and diverse ichnofaunas below the lowest occurrence of redlichiid trilobites of the Tsanglangpuian Stage of the Lower Cambrian.

The ichnofossils have been grouped into two assemblages: I—a lower fauna with simple burrows such as *Planolites* cf. *P. reticulatus* Alpert, *P.* cf. *P. beverleyensis* Billings, *Skolithos* and *Bergaueria*; and II – a higher fauna below redlichiid trilobites includes a rich and diverse assemblage with *Monomorphichnus monolinearis* Crimes, Legg, Marcos and Arboleya, *Monomorphichnus* sp., *Dimorphichnus, Diplichnites, Rusophycus didymus* (Salter), *Taphrhelminthopsis circularis* Crimes, *Gyrochorte, Aulichnites, Planolites corrugatus* (Walcott), *Phycodes palmatum* (Hall), *Skolithos, Kupwaria fusiformis* Shah and Sudan, *Bergaueria, Astropolithon* sp., *Bifasciculus, Gordia*, and *Bifungites*, among others.

The trace fossils of assemblage I are known from the basal part of the Razdain member of the Lolab Formation in Kashmir and have been assigned to the late Precambrian on the basis of microbiota (algae and acritarchs). The ichnofossils of assemblage II are ubiquitous and are recorded from the upper part of the Razdain member of the Lolab Formation in Kashmir, the Debasakhad Member of the Kunzam La Formation in Spiti and Lahul in the Higher Himalaya, and the Arenaceous member of the Tal Formation in the Lesser Himalaya. This assemblage in the Tal Formation is of special significance as it occurs in a sequence that has faunal assemblages known from the Meischucunian, Qiongzhusian and Tsanglangpuian Stages of the Lower Cambrian of China. The ichnofossils occur in an interval containing microfossils correlatable with Meishucunian Zone III of China. The appearance of such diverse and rich ichnofossils at this stratigraphic level (pre-trilobite) is a universal phenomenon, and, thus, in the absence of microfauna, can be used for demarcation of a Precambrian-Cambrian boundary for global correlation.

COMPLEMENTARY NOTES ON THE PRECAMBRIAN-CAMBRIAN TRANSITION IN MOROCCO

GEYER, Gerd, Paläontologisches Institut, Univ. Würzburg, Pleicherwall 1, D-8700 Würzburg, F.R.C.

The Precambrian-Cambrian transition in Morocco can be traced within a concordant, non-metamorphic sequence. In the Anti-Atlas Mountains, late Precambrian sedimentary rocks are represented by the well-known Adoudounian Group. This is traditionally divided into a Lower Limestone (and Dolomite) Formation, a middle Lie-de-vin Formation, and an Upper Limestone Formation at the top.

From the basal Lower Limestone Formation, only stromatolites of questionable biostratigraphic utility and a recently discovered skeletal alga have been reported. The Lie-de-vin Formation is a cyclic series of light and purple limestones, dolostones, marlstones, and siltstones that were deposited in a schizohaline and microtidal shallow basin. A strikingly oscillatory facies development produced sedimentary rhythms that are superimposed on a facies differentiation that was related to increased terrigenous influx from nearshore lithotopes. Although stromatolitic bioherms, thrombolites and low algal mats are frequent, shelly faunas are absent. The stromatolites indicate an age that corresponds to the late Riphean to the Vendian.

The Upper Limestone Formation yields the first skeletal faunas. These include trilobites and archaeocyathans as well as chancelloriids, hyoliths, *Coleoloides*? and the skeletal "algae" *Renalcis*, *Epiphyton*, *Telypothrix* and *Girvanella* among others. The appearance of skeletal fossils most probably was linked to a slight change in facies. Within the Upper Limestone Formation there is microfacial change from dark, micritic, and frequently finely laminated limestone and dolostones and associated argillaceous dolosiltites to massive oolitic pack/wackestones and marlstones. Reworked limestones have a high content of intraclasts with the interbeds consisting mainly of arenites. This indicates higher water energy connected with increasing water depths and more normal marine water chemistry. This facial development reflects paleogeographic developments associated with the opening of the epicontinental Souss Gulf from a lagoonal situation to open shelf environments.

The trilobites are mostly undescribed and belong to little-known groups. It can be shown that they represent a pre-*Fallotaspis* interval. Indirect correlation with the Cambrian of Siberia points at least to an age corresponding to that of Tommotian/Atdabanian boundary beds. This fauna might therefore include the oldest known trilobites. Similar trilobite species are only known from France where they can not be related to any biostratigraphical scheme.

In the High Atlas Mountains, the first trilobites are found at the top of a unit that lithologically resembles the Lie-de-vin Formation. These trilobites are very similar to those found in the Anti-Atlas. Archeocyathans first appear in a facies equivalent to the Upper Limestone Formation. They are accompanied by trilobites that suggest an age corresponding to that of the middle to upper *Fallotaspis* Zone and, therefore, are younger than the first archeocyathans of the Anti-Atlas Mountains. Consequently, the boundaries between lithostratigraphically correlative formations are apparently diachronous between the Anti-Atlas and High Atlas. The facies belts representing the Lie-de-vin Formation and Upper Limestone Formation moved towards the north and east with subsidence of the sedimentary basin.

ON SOME PROBLEMS IN RESEARCH ON EARLIEST SKELETAL FOSSILS

JIANG Zhi wen, Yunnan Inst. of Geol. Sci., Kunming, China

Although the appearance and stratigraphic succession of small shelly organisms in the Precambrian-Cambrian boundary interval have been the subject of considerable modern research, a number of questions about boundary interval organisms and correlations remain without satisfactory answers. The following is a brief list of topics discussed by the author in his presentation:

1) the origin of skeletalized animals and the stratigraphic sequence of their appearance,
2) a possible evolutionary sequence in materials used in skeletal construction,
3) the evolutionary relationships of such tube- and conch building animals as hyolithelminthoids, hyoliths and mollusks,
4) problems in reconstruction of multielement skeletons,
5) the taxonomy and systematics of early shelled organisms,
6) diachroneity in the local appearance of shelled taxa.

AVALONIAN SUB-TRILOBITIC SMALL SHELLY FOSSILS: FACIES AND DIAGENETIC RESTRICTIONS ON THE CORRELATION OF THE LOWEST CAMBRIAN

LANDING, Ed, New York State Geological Survey, The State Education Department, Albany, NY 12230; NARBONNE, Guy M., Dept. of Geol. Sci., Queen's Univ., Kingston, Ontario K7L 3N6; BENUS, Alison P., and MYROW, Paul, Memorial Univ., St. John's, Newfoundland A1C 3X5

The sub-trilobitic Lower Cambrian ('Etcheminian Series" of Matthew or "Placentian Series" of Landing *et al.*, In press) of southeastern Newfoundland is a mixed siliciclastic-carbonate platform succession that reaches a composite thickness of 1.4 km. In contrast to other approximately coeval, but much thinner reference sections in the Lower Cambrian, a relatively continuous record of deposition is preserved which shows the strong linkage of facies with the spatial and temporal distribution of a provincially distinct fauna. The limited correlation potential provided by the use of small shelly faunas in traditional biostratigraphic practice is well illustrated in southeastern Newfoundland.

Sub-trilobitic calcareous and phosphatic small shelly fossils are most abundant and diverse in carbonate and associated shale lithologies in upper member 3 and member 4 of the Chapel Island Formation and, above the Random Formation, in the Bonavista Group (inclusive of the Fosters Point Formation = lower "Smith Point Limestone;" Landing and Benus, this volume). These portions of the Placentian Series can be divided into 20 m- to 50 m-thick, typically asymmetrical, shoaling cycles that are terminated by deepening events. These shoaling cycles, when completely developed, feature a vertical succession of four major lithologies: 1) green, weakly bioturbated shale either with or without septarian nodules, 2) bioturbated purple to red shale with calcareous nodules in the upper part, 3) red shale and bedded fossil wacke- to packstones and algal mud mounds in decimeter-thick alternations, and 4) peritidal, condensed, thick (ca. 1.0 m), fossil hash bed with stromatolitic cap. These vertical facies cycles duplicate offshore-onshore lateral facies changes because lithofacies 4 is deposited directly on the shoreline during onlap of the Bonavista Group. Small shelly fossil diversity and abundance increases upward through a shoaling cycle; tommotiids, large hyolithids and orthothecids, helcionellids, halkierids, brachiopods, and conodont-like remains (*Fomitchella* and, higher up, *Rhombocorniculum*) are elements of the peritidal facies. By comparison, offshore, level bottom, siliciclastic muds feature a low diversity fauna (*Aldanella*, orthothecid-like organisms with probable planktic life mode, *Watsonella*) which also occurs in the peritidal facies. Remains of the level bottom fauna are infrequently preserved in the offshore muds because of early dissolution. Local pyritization and phosphatization in dysaerobic muds or casting by thin, storm-bed sands are the mechanisms for preservation of this offshore community. Faunal distributions in Avalon suggest that the Early Cambrian evolutionary radiation of small shelled metazoans is a shallow water phenomenon and that the potential for interprovincial correlation is limited to near-shore facies in the Precambrian-Cambrian boundary interval.

Avalonian, sub-trilobitic, small shelled organisms have extremely long stratigraphic ranges. For example, the species composing *Aldanella attleborensis* assemblage communities occur in upper member 3 and member 4 of the Chapel Island Formation and re-appear above the Random Formation (ca. 300 m-thick, locally) and persist through the Bonavista Group. The lowest appearance of this fauna in the Chapel Island does not record the earliest Cambrian evolutionary radiation but accompanies the longer-term shoaling event recorded by the vertical transition from deeper open shelf facies of member 3 into the nearer shore facies of member 4. A surprising local diachroneity in lowest appearance of this fauna is evident in the Chapel Island Formation. Marker units (meter-scale shoaling cycles, bedded limestones, storm beds) allow precise time correlations between Little Dantzig Cove and a section (Fortune North) located 20 km to the northeast. The *Aldanella attleborensis* assemblage appears 40 m lower in the Fortune North section than in the Little Dantzic Cove section. The two sections are of nearly identical thickness, and the diachroneity in first appearance of the fauna is due solely to the preservation of calcareous remains as pyritic molds in the more dysaerobic, offshore muds at Fortune North.

The *Aldanella attleborensis* fauna wanes and waxes in abundance and diversity through the Bonavista Group as it tracks onlap and offlap cycles. A number of species (*Coleoloides typicalis*, *Camenella baltica*, *Rhombocorniculum* spp., *Pelagiella* sp. indet.) first appear in abundance in the upper part of the Bonavista Group. This upper Tommotian- or Atdabanian-equivalent fauna appears with the development of strong offlap facies (lithofacies 3) that are regionally extensive and of relatively long duration. The local stratigraphic ranges of these species are of relatively limited significance for biostratigraphic correlation and are best interpreted as marking immigration events that followed evolutionary developments that took place elsewhere. *Coleoloides typicalis* is a key element of this upper fauna of the Bonavista Group. However, the species' lowest known occurrence is in limestones in the upper part of member 4 of the Chapel Island Formation, and its "acme" in the upper part of the Bonavista Group reflects major, regional changes in depth and substrate.

Trilobite-bearing limestones overlie the Fosters Point Formation (= lower "Smith Point Limestone') and form a 15 cm- to 2.0 m-thick interval at the top of the "Smith Point." The contact between the sub-trilobitic and trilobite-bearing rocks in this stratigraphic interval is a cryptic disconformity in all sections in southeastern Newfoundland. The amount of time not represented by rock at this unconformity is presently undetermined. However, the abrupt disappearance of many sub-trilobitic shelly animals and the equally abrupt appearance of a number of trilobites above the disconformity seem to imply a hiatus of considerable duration. The limestones and shales of the lower Brigus Formation are lithically comparable to those of the upper Bonavista Group, and this suggests that trilobitic facies did not exist elsewhere in Avalon at the same time that sub-trilobitic rocks were being deposited in southeastern Newfoundland.

THE PRECAMBRIAN-CAMBRIAN TRANSITION IN MOROCCO: PROBLEMS AND PERSPECTIVES

LATHAM, Andrew, Dept. of Geol., University College, Cardiff, CF1 XL, U.K.

The Precambrian-Cambrian transition of the Anti-Atlas Mountains in Morocco includes over 1200 m of dominantly carbonate strata of Vendian to Atdabanian age which are relatively undeformed.

The sequence beings with the Série de Base, which rests unconformably on older Precambrian, and continues with the Dolomie Inférieur, Série Lie-de-Vin, Calcaires Superieur and finally the Série Schist-Calcaire. The base of the Cambrian is conventionally placed at the base of the Calcaires Superieur, but an alternative view (Bertrand-Sarfati, 1981) places the earliest Cambrian at the base of the Lie-de-Vin, about 1000 m lower in the sequence. The oldest shelly fossils now described in the sequence are trilobites and archaeocyathans that are probably of Atdabanian age. These fossils occur some 200 m above the base of the Calcaires Superieur.

The sequence as a whole contains numerous cycles, each up to a few decameters thick, of intertidal and shallow subtidal facies. The lower part of the sequence, especially the Lie-de-Vin, contains abundant stromatolites and thrombolites associated with the trace fossils. Archaeocathan bioherms up to 50 m thick are present in the upper part of the Calcaires Superieur.

The presence of stromatolites, early trilobites and archaeocyathans provides an excellent means to bracket the Precambrian-Cambrian boundary. Small shelly fossils appear to be rare, however, and their absence poses a problem for detailed biostratigraphy of the boundary sequence.

Two major positive carbon isotope-excursions are known to occur in the sequence. They have been sugggested to correlate with the Riphean-Vendian and Tommotian-Atdabanian boundaries, respectively, and more detailed study of these isotope excursions should assist intercontinental correlation. Thin tuffaceous horizons are present and may provide radiometric ages within the sequence.

In general terms, a number of changes in sedimentation style are seen across the conventional Precambrian-Cambrian boundary at the top of the Lie-de-Vin. Dolomites and dolomitic limestones become less important up-sequence. The "Precambrian" sequence consists essentially of cycles and rhythms dominated by 1) laminated micrites with replaced evaporites, perhaps indicative of sabkha environments, overlain by 2) stromatolites and thrombolites. The Cambrian sequence is also cyclic and is characterized by 1) archaeocyathan biostromes/bioherms that are commonly associated with calcareous siltstones, 2) bioclastic limestones and 3) oolites.

The Moroccan Precambrian-Cambrian transition differs from those in the western hemisphere by being carbonate-dominated and apparently continuous. Its variety of facies, relative diversity of fossils, accessibility and good exposure make it an important sequence for the comparison of styles of carbonate sedimentation across the boundary, and the sequence has potential for precise location of the boundary itself.

ARE WE UNDERESTIMATING PRECAMBRIAN-CAMBRIAN PROVINCIALITY?

MCMENAMIN, Mark A.S., Dept. of Geol. and Geog., Mount Holyoke Coll., South Hadley, Ma 01075

A number of late Precambrian and earliest Cambrian marine taxa are now considered to have been cosmopolitan. Ediacarian "frondfossils" and "medusoids" are known from both Laurasian and Gondwanan sequences, as are the Early Cambrian shelly genera *Hyolithellus*, *Anabarites* and *Protohertzina*. It is difficult to assess endemism, however, in tubular/conical shelly and 'medusoid' taxa which have relatively few taxonomically distinctive morphologic characters. The question must be asked whether the cosmopolitan aspect of these early animal taxa is more apparent than real. Ediacaran and earliest Cambrian provinciality might well have been pronounced, but the fossils of this interval are not yet yielding sufficient morphologic information to allow recognition of the true geographic diversity. Similar arguments can be made to explain both the long ranges of Precambrian-Cambrian taxa and their supposedly low species-per-phylum ratio. Analysis of lineages consisting of morphologically simple fossils tends to result in under-estimates of provinciality, over-estimates of stratigraphic ranges, and under-estimates of species richness within higher taxa.

TRACE FOSSILS OF THE GOG GROUP, A LOWER CAMBRIAN TIDAL SAND BODY, LAKE LOUISE, ALBERTA

MAGWOOD, JAMES P.A., AND PEMBERTON, S. GEORGE, Dept. of Geol., Univ. of Alberta, Edmonton, Alta.

The Lower Cambrian Gog Group is a thick clastic sequence that can be correlated over much of the southwestern Canadian Rocky Mountains. In the Lake Louise area it unconformably overlies the Precambrian Miette Group. The Gog Group is interpreted as a near- to off-shore, tidally-influenced deposit formed on a prograding shelf. In the area of Lake Louise, Alberta, it consists of seven units that are alternations of thick, crossbedded orthoquartzites and interbedded quartz-rich shales and quartzites.

The Gog Group has an abundant and diverse assemblage of trace fossils but lacks body fossils in the Lake Louise area. The underlying Miette Group was not extensively examined, but this and other studies of it in the Lake Louise area have not resulted in the recovery of any trace fossils.

The quartzite units, one of which forms the basal unit, are made up of thick quartzite beds. Bedforms include flat to low angle lamination, trough cross bedding, planar cross bedding, and herringbone cross stratification. These sections represent tidal sand flats, beach deposits and migrating tidal sand bars. They contain occasional sparse *Skolithos*, *Diplocraterion*, and *Monocraterion*, as well as several beds of dense *Skolithos*. Some examples of *Protopaleodictyon* and *Paleodictyon* were found but are known mostly from float blocks.

The interbedded units contain beds of shale, resistant crossbedded quartzites, and thinly interbedded shales and quartzites. All three of these facies often form coarsening upward sequences. These sections were deposited in off-shore, quieter water conditions with much of the deposits representing the infilling of abandoned channels. Many beds are intensely bioturbated. Trace fossils include *Cruziana*, *Diplichnites*, *Monomorpichnus*, *Rusophycus*, *Trichophycus*, *Bergaueria*, *Chondrites*, *Cochlichnus*, *Paleophycus*, *Planolites*, *Scolicia*, *Skolithos* and *Teichichnus*. Possible *Zoophycos*-like fragments were found in float. The thinly interbedded sections contain the greatest diversity of trace fossils.

Several ichnospecies of *Cruziana* and *Rusophycus* were identified in the samples. These include: *C. arizonensis*, *C. furcifera*, *C. goldfussi*, *C. pormensis*, *C. stromnessa*, *C. rugosa*, *R. carinata*, *R. didymus*, *R. fasciculata*, *R. jenningsi*, and *R. rugosa*. *Cruziana rugosa* and *Rusophycus rugosa* along with *C. furcifera* and *R. fasciculata* are confined to the lower of the three interbedded quartzite and shale units. The other ichnospecies are found in the upper two units.

The presence of both shallow and deep water trace fossils is similar to that found in other Lower Cambrian shallow water marine deposits. The stratigraphic distribution of *Cruziana* and *Rusophycus* ichnospecies, however, is different than other distributions found in European Cambrian clastic sections.

ACRITARCHS AND THE CAMBRIAN EXPLOSION: AN EXAMPLE FROM THE EAST EUROPEAN PLATFORM

MOCZYDLOWSKA, Malgorzata, Dept. of Earth and Space Sci. Univ. of California, Los Angeles, CA 90024

The Lublin Slope in eastern Poland constitutes the western marginal zone of the East European Platform and is limited by the Teisseyre-Tornquist lineament. From the tectonic point of view, the Lublin Slope forms the western arm of the Volynian aulacogen which underwent subsidence and filled with a thick, continuous sequence of marine detrital sediments during Vendian and Cambrian times. An uninterrupted succession of planktic micoorganisms, regarded as prokaryotic photautotrophic cyanobacteria and algal protists (acritarchs), has been discovered in rocks that compose a transitional Vendian-Cambrian sequence.

Fossils of Proterozoic and Early Cambrian phytoplankton are cosmopolitan and are known from all kinds of marine shelf deposits and are independent of facies associations. In the late Proterozoic and Cambrian, acritarch assemblages allow several biozones to be distinguished. These zones can be successfully correlated within the East European Platform, Scandinavia, Scotland, Greenland and Canada.

Fossils of cyanobacteria and acritarchs were recovered from the Lublin Slope from all of the Precambrian-Cambrian boundary interval formations. The *Ven-*

dotaenia and *Sabellidites* Zones occur in the upper Proterozoic rocks of the Bialopole, Lublin and Wlodawa Formations. These zones have yielded a rich, but taxonomically simple, assemblage of cyanobacteria and spheroidal acritarchs. Virtually identical assemblages accompanied by venodtaenids, soft-body metazoans and "chitinous" tubular fossils (*Sabellidites*) have been reported from several upper Vendian sequences elsewhere. In the Lublin Slope, the Mazowsze Formation (*Platysolenites* Zone) yielded a distinctive assemblage of morphologically diverse acritarchs. A number of taxa are unique to the *Platysolenites* Zone. However, a number of them continue into known trilobite-bearing strata. This sudden radiation of diagnostic eucaryotic cyst-builders appears to represent an evolutionarily significant signal that is paralleled in the Lublin Slope by the radiation of Cambrian-type shelly fossils and trace fossils.

As it is the case in present-day marine ecosystems, prokaryotic and eukaryotic phytoplankton constitute the basic link in the trophic chain of early marine ecosystems. Detailed studies of marine phytoplankton across the Precambrian-Cambrian boundary in key sections can contribute substantially to the detection of comparable signals in the basic trophic levels of Early Cambrian ecosystems and provide the basis for the definition and detailed correlation of the Precambrian-Cambrian boundary.

ENVIRONMENTAL STRATIGRAPHY OF THE PROTEROZOIC-CAMBRIAN TRANSITION AND THE RECORD OF THE METAZOAN RADIATION EVENT IN WESTERN NORTH AMERICA

MOUNT, J. F., and SIGNOR, P.W., Dept. of Geol., Univ. of California, Davis, CA 95616

Within the Proterozoic-Cambrian transition of western North America, the fossil record of the metazoan radiation contains patterns of taxonomic diversification that might be useful in evaluating hypotheses and interpretations about the origin of higher taxa and the dynamics of their radiation. Tabulations of trace and body fossil diversity and first and last occurrences indicate that the Early Cambrian radiation involved at least three short-lived episodes of increased rates of origination. These originations were followed by extinction at the species, generic and family levels. This pattern seems to be consistent and synchronous between different regions in western North America.

Interpretation and evaluation of this record is dependent upon our ability to separate the evolutionary signal from other interference, such as the overprint of diagenesis, sampling effects, facies controls, and biogeography. The appearance of a given taxon within a stratigraphic unit is controlled by preservation, deposition and non-erosion of suitable habitat as well as by collection and processing methods and the evolutionary history of that taxon. In order to evaluate the role of environmental stratigraphy on the pattern of the metazoan radiation, we examined the paleoenvironmental context of the first and last occurrence of all reported Early Cambrian species, genera and families in three areas. These include Sonora, Mexico; the White-Inyo Mountains of eastern California and western Nevada; and western Canada. The sequence of depositional environments is quite different in each area, but the faunas are generally similar even at the species level.

Our results indicate that the first occurrences of shelly fossils appear to have been concentrated in carbonate and siliciclastic, shallow, subtidal environments. Less than five percent of species make their first occurrence in intertidal or deep subtidal sediments. Disappearance of these taxa are generally associated with shifts to intertidal environments. 75% of trace fossil first-occurrences are within units indicative of siliciclastic, shallow subtidal, high energy environments.

In light of these results, it is not surprising that, when examined in detail, the patterns of diversification of Early Cambrian faunas in western North America are closely tied to the stratigraphic occurrence of sediments that were deposited in shallow, subtidal environments. Therefore, the *apparent* relative timing of bursts in origination was controlled, at least partially, by the factors that influenced the spatial and temporal distribution of habitats. During the Early Cambrian, western North America was a mature passive margin dominated by broad, regional, thermotectonic subsidence. Shelf sedimentation was primarily controlled by episodic increases in the rate of eustatic sea level rise. The timing and magnitude of this sea level rise may be reflected ultimately in the seeming synchronous pattern of diversification during the Early Cambrian metazoan radiation.

SEDIMENTARY HISTORY OF THE CHAPEL ISLAND FORMATION, BURIN PENINSULA, NEWFOUNDLAND

MYROW, Paul, Dept. of Earth Sci., Memorial Univ., St. John's, Nfld. A1B 3X5

The Precambrian-Cambrian boundary is defined within the dominantly siliciclastic Chapel Island Formation. The boundary is located 2.4 m above the base of member 2. A detailed lithofacies analysis of this sequence allows the delineation of paleoenvironments and a three-part history of deposition. The first phase of deposition, represented by members 1, 2 and part of 3, records a major sea-level rise. This phase is initiated by a shift from the dominantly nonmarine redbeds of the underlying Rencontre Formation to the peritidal red and green sandstones and shales of member 1. Black to grey-green marine shales and silts from semirestricted nearshore settings are prominent at the top of member 1. The beginning of member 2 deposition records a shift toward a fluvial-dominated, storm-influenced deltaic system. A delicate balance between rate of subsidence, sedimentary input and sea level resulted in a thick accumulation of thin- to medium-bedded sands and silts within shallow subtidal to prodelta environments. Fine grained sediments accumulated rapidly and this resulted in a wide range of soft-sediment deformation features that are unusual in shelf settings. Continued rise in relative sea level caused a shift to the thinly laminated silts of member 3. This member was deposited in outer shelf settings below the influence of storm waves.

The second phase of deposition, represented by the upper part of member 3 and all of member 4, is a period of relative sealevel drop that is recorded by small scale, upward shoaling cycles, some of which are capped by algal limestones. The evidence suggests deposition in an oxygen-stratified inner shelf dominated by red (well oxygenated), green (less oxygenated) and pyritiferous grey (dysaerobic) mudstones. Deposition of algal carbonates was restricted to peritidal settings, in part due to climatic factors associated with the mid-latitudinal position of the Avalon Zone of Newfoundland at this time.

The third phase of deposition begins with a rapid relative sea-level rise and is followed by a progressive shallowing associated with a prograding wave-dominated shoreline. Green sandstones and siltstones of outer-shelf origin grade upward into inner-shelf to shoreface, red, hummocky cross-stratified, micaceous sandstones, and eventually into the quartz arenitic, macrotidal deposits of the Random Formation.

TRACE FOSSIL ZONATION OF THE PRECAMBRIAN-CAMBRIAN TRANSITION, WERNECKE MOUNTAINS, YUKON, CANADA

NARBONNE, G.M., Dept. of Geol. Sci., Queen's Univ., Kingston, Ontario K7L 3N6; HOFFMAN, H.J., Dept. of Geol., Univ. of Montreal, Que. H3C 3J7; FRITZ, W.H. and NOWLAN, G.S., Geological Survey of Canada, 601 Booth St., Ottawa, Ont. K1A 0E8

The Precambrian-Cambrian transition in the Wernecke Mountains is composed of a succession of alternating siliciclastic and carbonate units. Trace fossils are abundant and can be used in conjunction with Ediacaran megafossils and shelly fossils to define four biostratigraphic zones.

The basal zone (middle part of the post-tillite Windermere Supergroup) contains simple trace fossils (e.g. *Gordia, Planolites*) in association with a diverse assemblage of Ediacaran-type megafossils (e.g. *Charniodiscus, Cyclomedusa*). The second zone (uppermost part of the Windermere Supergroup) also contains simple trace fossils but apparently lacks Ediacaran fossils. A pronounced disconformity separates these strata from the overlying Vampire Formation. The Vampire contains numerous arthropod traces (e.g., *Rusophycus avalonensis, Cruziana*) and complex burrows (e.g. *Phycodes pedum, Treptichnus*). The basal strata of this zone contain a sparse assemblage of small shelly fossils dominated by *Anabarites trisulcatus* and *Protohertzina anabarica*. The uppermost zone (Sekwi Formation) also contains diverse arthropod traces and complex burrows (including *Plagiogmus*) in association with trilobites (e.g. *Fallotaspis, Nevadella*).

Correlation with the East European Platform suggests that the lower two zones correlate, respectively, with the Redkino and Kotlin "Horizons" of the Valdai "Series" (upper Precambrian) whereas the upper two zones correlate, respectively, with the Lontova and Talsy "Horizons" of the Baltic "Series" (Lower Cambrian). Trace fossils are an effective means of correlation in siliciclastic facies in the Precambrian-Cambrian transition.

THE PRECAMBRIAN-CAMBRIAN TRANSITION IN THE CHAPEL ISLAND FORMATION, BURIN PENINSULA, SOUTHEASTERN NEWFOUNDLAND, CANADA

NARBONNE, Guy M., Dept. of Geol. Sci., Queen's Univ., Kingston, Ontario K7L 3N7; LANDING, Ed, New York State Geological Survey, The State Education Department, Albany, NY 12230; MYROW, Paul, and ANDERSON, Michael M., Dept. of Earth Sci., Memorial Univ., St. John's, Nfld. A1B 3X5

The Chapel Island Formation is a late Precambrian-Early Cambrian unit composed of fine-grained siliciclastics with minor carbonates. Fossils are abundant and include trace fossils, small shelly fossils, soft-bodied megafossils, vendotaenid algae, and organic-walled microfossils.

Three globally-correlatable trace fossil zones can be recognized in the Chapel Island Formation. Member 1 and the lower 2.4 m of member 2 constitute the *Harlaniella podolica* Zone. This zone exhibits a low diversity assemblage of simple burrows that include two ichnogenera which are apparently restricted to the late Precambrian. Correlation can be made with the Kotlin "Series" of the East European Platform and with age-equivalent strata in Australia, northwestern Canada and other areas. This zone is immediately succeeded by the *Phycodes pedum* Zone which characterizes the lower part (2.4 – 150 m above the base) of member 2. This zone lacks Precambrian-type trace fossils and, instead, is dominated by several widespread Cambrian-type forms. *Phycodes pedum* is an especially valuable "index fossil" for the basal Cambrian because this easily recognized form occurs in sub-trilobite Cambrian strata on virtually every continent. The upper sub-trilobite zone, the *Rusophycus avalonensis* Zone, characterizes the remainder of the Chapel Island Formation and all of the overlying Random Formation. This zone includes all ichnospecies present in the *Phycodes pedum* Zone, plus arthropod burrows (e.g. *Rusophycus avalonensis*), complex dwelling burrows (e.g. *Diplocraterion* sp.) and feeding burrows (e.g. *Taphrhelminthopsis circularis*). These trace fossil zones are readily recognizable in siliciclastic facies worldwide but are more difficult to distinguish in the carbonate facies of Central Asia.

Small shelly fossils occur sporadically throughout the Chapel Island Formation and provide a basis for correlation with sections in the carbonate facies belts. The primary controls on the stratigraphic occurrence of small shelly fossils appear to be related to paleoenvironmental and diagenetic factors, with evolutionary and immigration events functioning only as second order controls. A *Sabellidites cambriensis* assemblage occurs in the upper part of member 1 and the lower half of member 2 of the Chapel Island Formation; a similar assemblage characterizes Precambrian-Cambrian boundary strata in the East European Platform, Siberia and China. With the exception of a single occurrence of "*Ladatheca*" *cylindrica* near the top of member 2, no shelly fossils occur in the upper half of member 2 or in the lower part of member 3. Carbonate and shaly beds near the top of member 3 and throughout member 4 contain a relatively diverse *Aldanella attleborenis* assemblage; this assemblage is broadly similar in character to those from the lower part of the Tommotian Stage of the Siberian Platform but may represent an older fauna. The *Aldanella attleborensis* assemblage is not present in the sandstones that characterize member 5 of the Chapel Island Formation and the overlying Random Formation but recurs in the carbonates and the shales of the overlying Bonavista Group.

The co-occurrence of trace fossils and small shelly fossils in a relatively thick (ca. 1000 m of sub-trilobite Cambrian) and essentially continuous section of marine strata makes the Burin Peninsula an excellent locality for a Precambrian-Cambrian boundary statotype. Correlation with sections in the East European and Siberian platforms suggest that the basal Cambrian trace fossil zone (*Phycodes pedum* Zone) approximately corresponds with the lowest shelly fossil zone (*Sabellidites* assemblage/Nemakit Daldyn fauna) in these sections.

UPPER VENDIAN AND LOWER CAMBRIAN TRACE FOSSILS FROM SOUTHEASTERN POLAND

PACZESNA, Jolanata, Geol. Inst., Stratigraphy Dept., Rakowiecka 4,00-975 Warszawa, Poland

The upper Vendian and Lower Cambrian sequence from the Lublin region, southeastern Poland, has yielded a rich and diversified ichnofauna.

The lowest part of the Precambrian-Cambrian transition interval includes the Bialopole and Lublin formations (upper Vendian). The Bialopole Formation is composed mainly of sandstones, and no trace fossils have been found in this unit.

The overlying Lublin Formation, which is assigned to the late Vendian on the basis of vendotaenids and simple forms of metazoans, is composed of interstratified sandstones and mudstones. The Lublin Formation yielded a rich, ethologically diversified but taxonomically problematical assemblage of trace fossils. This assemblage includes *Torrowangea rosei*, *Planolites montanus*, *Planolites* ichnosp., *Chondrites* ichnosp., *Palaeopascichnus delicatus*, *Cochlichnus* ichnosp. and *Helminthopsis irregularis*. The trace fossil assemblage of the Lublin Formation is monotonous in its ichnogenus composition, and the morphology of the trace fossils is not complex. A characteristic feature of these upper Vendian traces is that their orientation is horizontal relative to the sediment surface.

The *Sabellidites* Zone, which has been traditionally assigned to the Lower Cambrian in Poland, has very rare trace fossils. These include: *Planolites beverleyensis*, *Planolits montanus*, *Gordia* ichnosp., and *Bilinichnis simplex*. This zone is composed mainly of sandstones with local interbeds of mudstones.

The abundance and diversity of trace fossils abruptly increases in the overlying *Platysolenites* Zone. The age of this assemblage is undoubtedly Early Cambrian. This zone features a large number of traces representing a taxonomically and ethologically diverse suite. The *Platysolenites* Zone has yielded *Treptichnus lublinensis*, *Treptichnus triplex*, *Treptichnus* cf. *bifurcus*, *Phycodes pedum*, *Neonereites uniserialis*, *Neonoreites biserialis*, *Gyrolithes polonicus*, *Bilinichnus simplex*, *Bergaueria major*, *Mammillichnis aggeris*, *Planolites montanus*, *Planolites beverleyensis*, *Teichichnus* ichnosp. and *Monocraterion* ichnosp. These trace fossils occur mainly in intercalated mudstones and sandstones.

The sediments of the Lublin Formation were deposited in shallow marine environments that probably represent quiet, lagoonal, low energy conditions. Sediments overlying the *Sabellidites* and *Platysolenites* zones were deposited in slightly deeper, offshore, tidal conditions.

The distribution and distinctiveness of the trace fossil assemblages suggest their utility in delineating and correlating the Precambrian-Cambrian boundary in southeastern Poland.

STRATIGRAPHIC COMPLETENESS AND THE LIMITS OF BIOSTRATIGRAPHIC CORRELATION IN EARLIEST CAMBRIAN SEDIMENTS

SIGNOR, Philip W., Dept. of Geol., Univ., of California, Davis, CA 95616; SADLER, P.M. Dept. of Earth Sci., Univ. of California, Riverside, CA 92521; and MOUNT, J.F., Dept. of Geol., Univ. of California, Davis, CA 95616

Sedimentation is an intermittent process in most depositional environments. Rates of sediment accumulation tend to be quite variable both when and where sedimentation occurs. This discontinuity in process and variability in rate has important but unappreciated implications for biostratigraphic correlations of Lower Cambrian strata and for interpretations of the fossil record of early metazoans.

A variety of factors interact to control the appearances of taxa in the fossil record. These include diagenesis, biogeographic effects, facies controls and sampling biases. No single section, regardless of that section's stratigraphic completeness or potential acuity, will provide an accurate record of the metazoan diversification. Reconstruction of the record of metazoan diversification will require compilation of sequence data from many well-correlated sections that represent a variety of facies. In this sense, much of the fuss over which section to designate as the type of the Precambrian-Cambrian boundary is misplaced; each well-preserved section will play an important role and none should be overlooked.

It follows from the arguments above that the most important criteria for the type section are that it be a relatively complete section that includes sediment deposited throughout the latest Proterozoic and earliest Cambrian and that it contain a fauna that can be correlated throughout the world. The latter criterion has received considerable research attention but the former has not. It is not sufficient to claim that individual sections are complete; continuity of deposition must be documented through a combination of careful field work and paleoenvironmental analysis.

There are grounds to suspect that two of the primary candidates for designation as the type section are, in fact, relatively incomplete. The Ulukhan-Sulugur and Meishucun sections are surprisingly thin and both contain apparent disconformities and unconformities. The Ulakhan-Sulugur section contains several facies changes and at least two disconformities. The Tommotian portion of the section is less than 100 m thick and represents facies where sediments can accumulate quickly. The Meischucun section is no thicker and, judging from the facies represented, probably contains several diastems. The net rate of deposition, ignoring compaction, is apparently less than 10 m/1 myr (Bubnoff units) for both sections. Comparing these rates of accumulation to those compiled by Sadler, it is evident that neither section is notably thick for the amount of time represented.

Given the importance of biostratigraphic resolution to the problems of sequencing the appearance of metazoan clades, it might be desirable to seek sections that are thicker and more complete even if those sections are less fossiliferous.

EVENTS AND PHYTOPLANKTON-BASED BIOSTRATIGRAPHY AROUND THE PRECAMBRIAN-CAMBRIAN TRANSITION

VIDAL, Gonzalo, and MOCZYDLOWSKA, Malgorzata, Dept. of Earth and Space Sci., Univ. of California, Los Angeles, CA 90024

Fossils of plant protists (acritarchs) and cyanobacteria are extremely abundant in polyfacial rock sequences around and across the PC-C transition. Upper Proterozoic epicontinental and deep shelf sequences in the Urals, Scandinavia, the East European Platform and North America predating the Late Proterozoic Varanger glacial event(s) (ca. 650 Ma) are dated at about 850-700 Ma and yield relatively highly diversified assemblages of morphologically complex acritarchs accompanied by a wide variety of cyanobacterial microfossils. Coexisting deep shelf depositional settings seem to have harbored a comparatively depauperate biota of largely cyanobacterial composition. The Pre-Varangerian assemblage is replaced without descendents by a morphologically simple assemblage of phytoplankton dominated by leiosphaerids and cyanobacteria which inhabited the perimeter of the continental masses. The microfossils are recovered from marine glacial and inter-glacial (Varangerian), and post-glacial (late Vendian; *Vendotaenia* Zone and *Sabellidites* Zone) sequences in the Fennoscandian Shield and the Lublin Slope of the East European Platform. In the latter area, a distinctive radiation of diagnostic Paleozoic-type acritarchs has been recorded in continuous polyfacial shelf sequences. The radiation event abruptly replaces the taxonomical simplicity and monotony of the late Vendian-type assemblage in the *Sabellidites cambriensis* Zone.

We believe that the observed changes in assemblages of fossil phytoplankton communities record a geologically rapid invasion of shelf waters by effective eukaryotic photoautotrophs. These newcomers evolved rapidly during the remainder of Paleozoic time and gave rise to an efficient and long-lasting stock of plant protists. Their rapid rise in the Proterozoic/Cambrian boundary interval may have depended on the evolution of strategies for the recovery of available nutrients and on shifting nutrient levels at the onset of the Vendian glacial events(s). Such strategies may have led to the colonization of deeper water and/or more offshore habitats. These developments may be the cause of sharply defined changes in phytoplankton communities around the PC-C transition.

As trophic levels underwent drastic changes, the initial evolutionary radiation of marine photoautotrophs must have preceeded the record of radiation among protist and metazoan heterotrophs. The known stratigraphically well-defined events are apparently real, and major changes that affect photoautotrophs and heterotrophic protists are mirrored by both the sudden radiation of skeletal faunas and changed patterns of bioturbation. The initial events at the base of the trophic chain constitute important, evolutionarily significant biostratigraphic markers for defining and timing the PC-C boundary/transition.

THE PRECAMBRIAN-CAMBRIAN BOUNDARY STRATOTYPE CANDIDATE AT MEISHUCUN

YUSHENG Xing, Institute of Geology, Chinese Academy of Geological Sciences, Beijing

The Meishucun section is located on the southwestern corner of Dianchi Lake near Kunming, Yunnan. It is a readily accessible section.

The upper Sinian and Lower Cambrian are well exposed in this area. The oldest strata are the upper Sinian Wangjiawan Formation (Doushantuo Formation). This is overlain (in ascending order) by the Donglongtan Formation, the Yuhucun Formation and the Qiongzhusi Formation.

The Yuhucun Formation is subdivided into five members. In ascending order these are the Jiucheng Member (with macroscopic algae, *Chuaria* and *Shouhsienia*), the Baiyanshaeo Member (with micropalaeophytes), the Xiaowaitoushan Member (with the first appearance of small shelly fossil assemblage 1 0.8 m above its base), the Zhongyicun and Dahai Members (with abundant small shelly fossils and trace fossils).

The Qiongzhusi Formation is subdivided into the Badaowan Member (below) and Yu'anshan Member (above). The first member yields small shelly fossil assemblage 3 while the second has trilobites (*Parabadiella*, *Mianxiandiscus*, *Wutingaspis*, *Eoredlichia*, etc.) and archaeostracods (*Hanchungella*, *Kunmingella*, etc.).

The earliest small shelly fossils from the Meishucun section can be separated into three assemblages. From older to younger these include the following:

1. *Anabarites-Protohertzina* assemblage in the Xiaowaitoushan Member (beds 1 and 2) and lower and middle part (beds 3-6) of Zhongyicun Member,
2. *Paragloborilus-Siphogonuchites* assemblage in the upper part (bed 7) of the Zhongyicun Member and Dahai Member (bed 8).
3. *Sinosachites* assemblage in the Badaowan member (beds 9-12).

On the basis of the biotic succession, two horizons can be chosen in the Meishucun section for the Precambrian-Cambrian boundary. One of them is located at 0.8 m above the base of Xiaowaitoushan member (point A) where the first small shelly fossil assemblage appears. The second is at the base of bed 7 (Zones 1/2 contact) (point B). This horizon was favored by the Precambrian-Cambrian Boundary Working Group in January, 1984, as the global Precambrian-Cambrian boundary stratotype horizon.

The Meishucun boundary section can be correlated with sections in western and northern Sichuan, central and northern Guizhou, western Hubei, southern Shaanxi, western Zhejiang, southern Xinjiang and some others sections of China. Intercontinental correlations are possible with the sections in southwestern Mongolia, Siberia, Kazakhstan, the Himalayan Region, the Mackenzie Mountains, Newfoundland and other regions.

FIELD TRIP

Faunas and depositional environments of the Upper Precambrian through Lower Cambrian, southeastern Newfoundland

---

Ed Landing[1], **Guy M. Narbonne**[2], **Paul Myrow**[3]*, **Alison P. Benus**[3], **and Michael M. Anderson**[3]

[1] New York State Geological Survey, The State Education Department
[2] Department of Geological Sciences, Queen's University
[3] Department of Earth Sciences, Memorial University
* current address, Geology Department, Colorado College

SUMMARY (EL)

A key purpose of this field trip is to illustrate the stratigraphy, paleoenvironments, biostratigraphy and correlation potential of the Precambrian-Cambrian stratotype (Stop 3B, Figure 4) recently proposed by Narbonne *et al.* (1987). This section will be placed into its geographic and geologic context by including stops at older Precambrian and younger Cambrian localities. It is the authors' intention during this field trip to emphasize four fundamentally important aspects of the Precambrian-Cambrian boundary interval in southeastern Newfoundland:

1) The sub-trilobitic Lower Cambrian is approximately 1.4 km thick [Chapel Island Formation, members 2-5, ca. 840 m; Random Formation, to 300 m; Bonavista Group, inclusive of lower "Smith Point Limestone" (= Fosters Point Formation, see Landing and Benus, this Bulletin), to 275 + m] and is significantly thicker and probably more complete stratigraphically than other proposed Precambrian-Cambrian boundary stratotypes.

2) Two major, unconformity-bounded, onlap-offlap sequences [a) upper Rencontre Formation through Random Formation and b) Bonavista Group] are present in the sub-trilobitic interval. The later parts of these sequences may correspond, approximately, to the a) Nemakit-Daldyn Formation and lowermost part of the Meishucunian Stage (*Circotheca-Anabarites-Protohertzina* Zone) and b) the lowermost Tommotian Stage and upper part of the Meishucunian Stage ("*Paragloborilus*"-"*Siphogonuchites*" Zone) (see Landing and Benus, this Bulletin).

3) Small shelly faunas are typically abundant and diverse only in shallow water facies in southeastern Newfoundland while species known also from Siberia and southern China have extremely long stratigraphic ranges on the Avalon Platform. These features suggest that the lowest occurrence of a Cambrian-aspect trace fossil assemblage provides a far more reliable and correlatable horizon in the definition of a Precambrian-Cambrian boundary stratotype (see Narbonne *et al.*, 1987).

4) The absolute age of the Precambrian-Cambrian boundary appears to be far less than the ca. 600 myr to 570 myr values proposed by many authors (see Conway Morris, this Bulletin). Precambrian dates in southeastern Newfoundland include ca. 750 myr for the onset of rift-related volcanism and volcaniclastic sedimentation, 600 myr to 530 myr dates for intrusives that are nonconformably overlain by Cambrian sediments, and a 565 myr date on the age of soft-bodied, Vendian-aspect faunas at Mistaken Point (A.P. Benus, Abstract, this Bulletin).

GEOLOGICAL SETTING (EL)

Southeastern Newfoundland east of the Hermitage Bay – Dover fault system (Figure 4) has a geological history and stratigraphic record which are comparable to those of the coastal northeastern United States, southern New Brunswick, northern mainland Nova Scotia, Cape Breton Island, Wales and central England (see Rast *et al.*, 1976). This eastern terrane of the Appalachians, or the Avalon Zone, collided with the easterly remnants of the Paleozoic Iapetus Ocean (Gander Zone) during the Devonian Acadian orogeny (see Williams *et al.*, 1974).

The Avalon Zone of southeastern Newfoundland is areally dominated by relatively unmetamorphosed, upper Precambrian volcanics, siliciclastics, and local mafic and granitoid intrusives. An important compressive event, frequently designated the "Avalonian orogeny" and equated with the Cadomian orogeny of western Europe, deformed this older sequence. Erosion preceeded the onlap of the overlying, siliciclastic-dominated upper Precambrian to Ordovician marine platform sequence (Figure 4). Angular unconformities and non-conformities (Stop 2A) are present at many localities at the contact between the upper Precambrian and the overlying uppermost Precambrian through Ordovician. The Acadian orogeny is probably responsible for the down-folding and -faulting that preserves the uppermost Precambrian through Ordovician in a number of outliers across southeastern Newfoundland (Figure 4). Extensive areas of Late Devonian granitic intrusives that accompanied the Acadian orogeny, and which also intrude Silurian(?)- and Devonian-age subaerial to fluvial clastics and local limestones, are present along and adjacent to the Hermitage Bay – Dover fault system. The youngest rocks of the area occur in the Burin Peninsula and include Carboniferous granites and fluorite-bearing pegmatites and local outcrops of Lower Carboniferous fanglomerate, fluvial sandstones, and thin limestones. These intrusives and sediments accompanied the Alleghenian (e.g. Hercynian) orogeny. Upper Triassic to Lower Jurassic mafic intrusives and rift-associated sediments that record the opening phase of the modern Atlantic in the Maritime Canadian and United States' Appalachians are not present in subaerial outcrops in southeastern Newfoundland (see O'Brien *et al.*, 1983, for a regional summary of Avalonian geology).

Glacial drift, a dense spruce forest and bogs cover the bedrock in most interior localities. However, a deeply incised coast line with extensive sea cliffs, fjords, and shore outcrops as well as local road and river cuts have allowed southeastern Newfoundland to become a standard of reference in the interpretation of the geological history of the Avalon Zone.

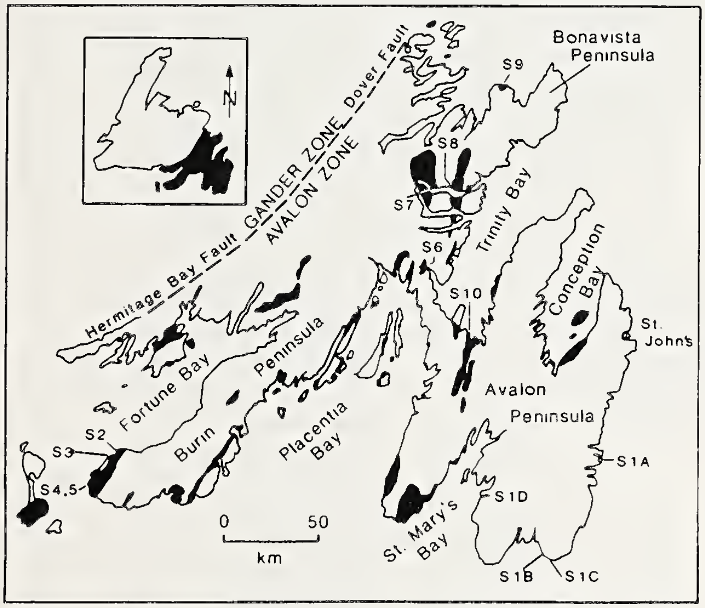


Figure 4. The Avalon Zone in Newfoundland. Figure shows uppermost Precambrian through Ordovician inliers (in black) and location of field trip stops (S 1A to S 10).

UPPER PRECAMBRIAN

Stratigraphy (EL)

Among the various tectonic models that have been proposed for the upper Precambrian of the Avalon Zone (see O'Brien and King, 1982), a geological history involving initial rifting and subsequent compression appears to be most appropriate to the stratigraphic record in the eastern part of the Avalon Peninsula (King, 1979, 1986; see Figure 6). This geologic history includes a) an early ensialic rift setting with bimodal volcanism and associated subaerial to shallow marine volcaniclastic deposition (Harbour Main Group) (ca. 1.5 + km thick), b) subsequent deep marine (lower slope to rise) turbiditic sedimentation (Conception Group; e.g. Williams and King, 1979) at a rapidly subsiding margin with diminishing volcanism (ca. 3-5 km thick), c) southerly progradation of dark shales and thin sands of a slope facies (St. John's Group, ca. 1.6 km thick), d) southward progradation of coarsening-upward shelf sandstones and laterally equivalent fanglomerates (Signal Hill Group, 3-8 km thick), and e) very late Precambrian folding (Avalonian orogeny).

The Gaskiers Formation (Figure 5, Stop 1D) is a lithically distinctive unit that is a key aid in correlations in the southern and eastern Avalon Peninsula. The Gaskiers, a deep marine deposit with prominent diamictites bearing clasts to two meters in diameter, conglomerates and sandstones in channelized bedding units, and rhythmites with probable dropstones (see Williams and King, 1979), lies below the Mistaken Point Formation with its soft-bodied metazoan faunas (Stop 1C). The Gaskiers Formation may correlate with glacial deposits that occur below Vendian soft-bodied faunas in a number of localities worldwide (e.g. Cloud and Glaessner, 1982).

Correlations from the eastern Avalon Peninsula into the westernmost Avalon Peninsula and the Burin Peninsula are problematical because of westerly-increasing deformation, replacement of the eastern siliciclastic sequence by apparently coeval volcanics and volcaniclastics in the west, and by accompanying facies changes within the siliciclastics. The conventional correlation (Figure 5) equates the Harbour Main Group with the Love Cove Formation (volcanics and volcaniclastics) and the Conception Group with the Connecting Point Group (fine-grained, siliceous turbidites). This suggests an apparent equivalency of the Bull Arm Formation (subaerial mafic to acidic volcanics in the western Trinity Bay and Isthmus of Avalon regions) with post-Conception Group strata. However, Brückner (1977) has provided a cogent argument against this customary east-west correlation. Brückner (1977) has described a tilloid within the fine-grained siliceous mudstones and arkosic sandstones that form the middle part of the Big Head Formation. If this tilloid at the northeastern end of Placentia Bay is coeval with the Gaskiers Formation, then the Connecting Point Group – Big Head Formation sequence is the lateral equivalent of the Conception Group, and the Bull Arm Formation represents part of a volcanic terrane that contributed the thin ash beds to the deep water turbiditic sequence of the Conception Group in the southeast (Stop 1C).

The upper Precambrian of the southern Burin Peninsula is significantly different from that of the Avalon Peninsula (see Strong, 1979). The Rocky Harbour Group (ca. 1.9 km thick) changes from a coarse-grained conglomerate with rhyolite and ignimbrite clasts in the north to a finer-grained turbiditic sequence in the south. The Rocky Harbour is the tectonic and possible temporal equivalent of units deposited in a rift and early cooling margin setting in the eastern Avalon Peninsula (Figure 5). The Burin Group (ca. 5 km thick) is a unique lithologic assemblage in the Avalon Zone of southeastern Newfoundland. It consists of interbedded mafic pyroclastics and waterlain volcaniclastics, pillow basalts, and a thick (Wandsworth Gabbro) diabasic sill. Strong (1979; Strong *et al.*, 1978) interpreted the Burin Group as a product of rifting that led to basaltic intrusions and a geographically restricted "oceanization" of this part of the Avalon Zone. However, limestone beds, including domal stromatolitic build-ups, in the middle part of the Burin Group suggest shallow water environments for parts of the Burin Group. The relationship of the Burin Group to evolution of the western Avalon Zone is problematical because the known contacts of the group are fault zones (Strong *et al.*, 1978). U-Pb dates on zircons from the Wandsworth Gabbro sill (1.5 km-thick) provide an age of ca. 763 myr. This indicates that the Burin Group is an older igneous terrane than the "Pan-African" volcanics of the Rock Har-

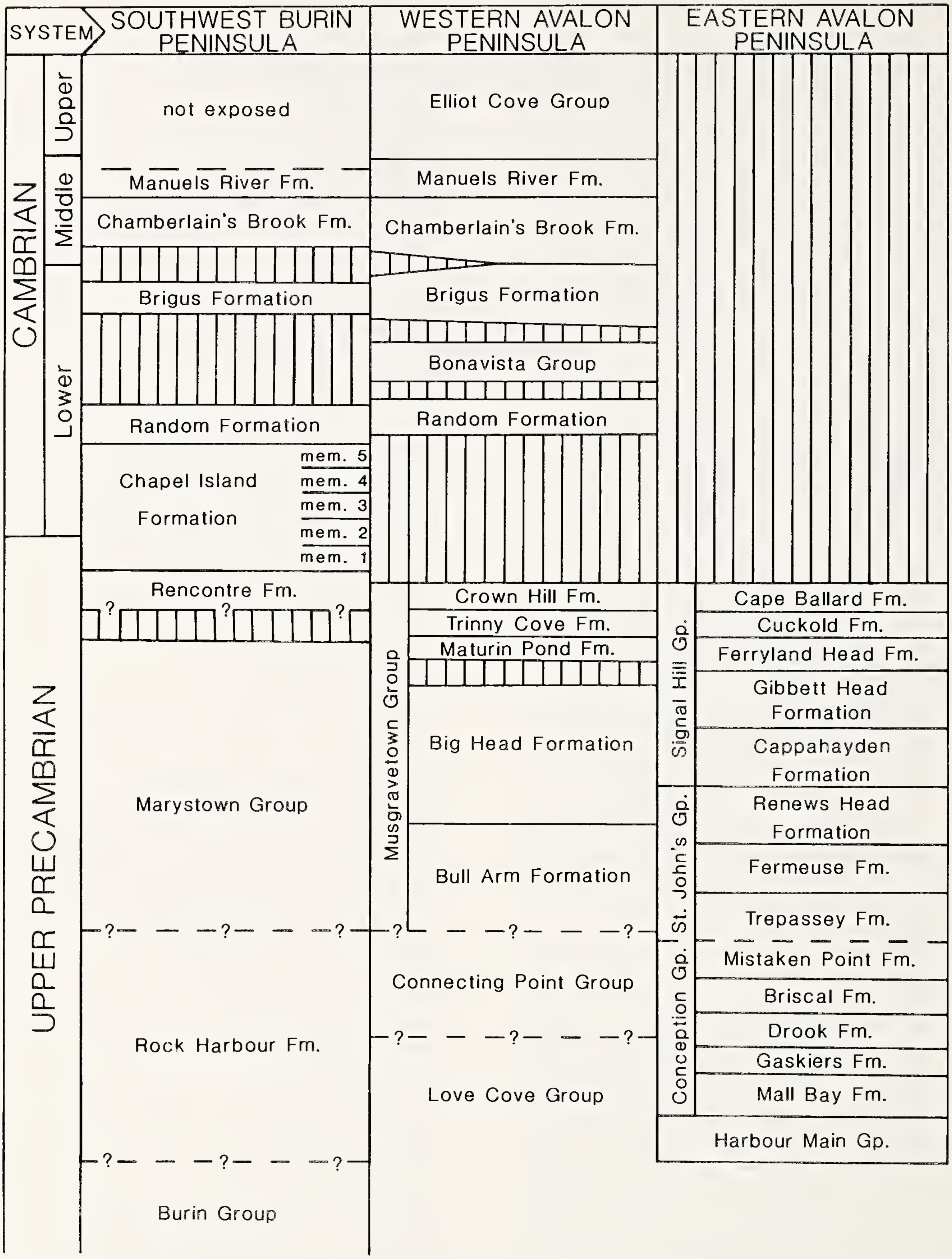


Figure 5. Upper Precambrian to Cambrian correlations, Avalon Zone, southeastern Newfoundland. Upper Precambrian correlations after King (1979) and Strong (1979). As discussed in the text, the Big Head Formation may be a lateral equivalent of part of the Conception Group while the Trepassey Formation may be better grouped in the Conception Group. Recent dating of rocks from the Burin Group (Krough *et al.*, In press) indicates that these ophiolites are significantly older than other volcanics of the region. See Landing and Benus (this Bulletin) for definition of the Bonavista Group. Vertical rulings indicate major unconformities.

bour, Marystown and Harbour Main groups and the intrusives of the Holyrood granite (Krogh *et al.*, In Press). The Marystown Group (10 + km thick) represents dominantly subaerial volcanism (rhyolite flows, tuffs, ignimbrites), associated volcaniclastic deposition and minor mafic extrusives in the southern and central Burin Peninsula. The Marystown group has been interpreted as a geographically restricted bimodal volcanic terrane associated with an anorogenic or extensional environment in the late Proterozoic (Strong *et al.*, 1978; O'Brien *et al.*, 1983).

Upper Precambrian paleontology in southeastern Newfoundland is at a very early stage of development. Soft-bodied metazoans occur at a number of horizons at the classic Mistaken Point locality (Stop 1C) but have received only preliminary descriptive treatments (Anderson and Misra, 1968; Misra, 1969b; Anderson, 1978, Anderson and Conway Morris, 1982). The biostratigraphic sequence and significance of these faunas in southeastern Newfoundland has not yet been documented. However, Vendian-aspect metazoans are known at least as low as the Drook Formation (Stop 1B) and through the Mistaken Point and Trepassey Formations (Stop 1C).

Soft-bodied metazoans in the southeastern Avalon Peninsula occur in a deep water, turbiditic sequence and are preserved within hemipelagic mudstones, tuffs, or tuffaceous sediment (A.P. Benus, Abstract, this Bulletin). Unfortunately, this depositional environment has been interpreted in a number of publications as shallow water on the basis of associated "asymmetrical wave ripples" (e.g. King, 1979; Williams and King, 1979). These "asymmetrical wave ripples" are readily demonstrated to be pseudoripples that reflect intersecting standing waves on a tectonic slip cleavage (Stop 1C).

Organic-walled microfossils have been recovered from preliminary samples from upper Precambrian units in the Avalon and Bonavista Peninsulas (Hofmann *et al.*, 1979). The biostratigraphic potential of the low diversity suite of spheroids and filiments recovered from this region does not seem particularly promising at present.

Avalonian Orogeny (EL)

The effect of late Precambrian deformation in southeastern Newfoundland is curiously understated in many recent tectonic syntheses even though the "Avalonian orogeny" was first proposed (Lilly, 1966) in this region. Very divergent opinions on the style of Avalonian deformation and the nature of the contact of the uppermost Precambrian and Cambrian with the upper Precambrian in southeastern Newfoundland are held by various authors. For example, Keppie (1982, p. 125) asserted a "general absence of such deformation in the Avalon Peninsula" and even excluded southeastern Newfoundland from the latest Precambrian terrane collisions which he imagined as leading to the assembly of an Avalon Zone. Alternatively King (1979) interpreted an episode of uplift largely to the north of the modern Avalon Peninsula that supplied upper Precambrian arkosic sediments (Signal Hill Group) and a subsequent onlap of Cambrian sediments (Random Formation) with, seemingly, little evidence of a regionally extensive unconformity at the base of the Cambrian. O'Brien *et al.* (1983) also regarded the Avalonian orogeny as a geographically limited event in southeastern Newfoundland. The latter authors believed that the orogeny was dominated by extensional tectonism that limited the sub-Cambrian Avalonian unconformity to horsts and allowed continuous deposition from the Proterozoic into the Cambrian in grabens to the southeast.

A view which is preferred herein is that the Avalonian orogeny is a regionally extensive, key event in the geological history of southeastern Newfoundland that 1) preceeds the region's transition into a nearly passive, shallow marine platform, 2) is associated with a change from a generally southerly- to a westerly-facing depositional slope, and 3) is marked by profound unconformity at the base of the uppermost Precambrian and Cambrian. McCartney (1969; see King, 1979, Fig. 1) noted that the Random Formation and higher Lower Cambrian units overlie progressively older Precambrian units on a west-to-east transect across the Avalon Peninsula. For example, the Random overlies upper Signal Hill equivalents in eastern Trinity and Placentia Bays while higher Lower Cambrian units overlie units as low as the Holyrood Granite and Harbour Main Group in Conception Bay (see Landing and Benus, this Bulletin; Bacon Cove, Brigus South Point and Duffs localities). A stratigraphic cutout of approximately ten kilometers of the upper Precambrian prior to Lower Cambrian onlap is indicated by these relationships. Local angular unconformities between nearly vertical upper Precambrian sediments and overlying gently dipping Cambrian units are known at several localities in Conception Bay (McCartney, 1969; Landing and Benus, this Bulletin) and seem to be compatible with a compressive rather than an extensional regime in the late Precambrian. Angular unconformities and stratigraphic cut-out at the Avalonian unconformity are well known in the southeastern Trinity Bay region on the basis of divergences in fold axes in the upper Precambrian (nearly east-west) and Cambrian (nearly north-south) (Hutchinson, 1953) and by 1.3 km of cut-out of the upper Precambrian below the Random Formation (McCartney, 1957).

Older beliefs that the quartzites and siltstones of the Random Formation are depositionally continuous with the underlying Musgravetown Group (Jenness, 1963; McCartney, 1967) were first challenged by Fletcher (1972) on the basis of sections along southeastern Placentia and southwestern St. Mary's Bays. In this region, a unique chert and rhyolite pebble conglomerate occurs at the base of the Random Formation, and a minimal stratigraphic cut-out of 140 m of upper Precambrian is demonstrable across Cape St. Mary's. Fletcher's (1972) proposals that the Random is depositionally unrelated to the upper Precambrian and that apparent local conformable relationships of the Random in the Avalon and Bonavista Peninsulas are due to reworking of eroded upper Precambrian sediments have been corroborated by subsequent work in the southwestern Burin Peninsula. In this region, a conformable sequence of the Rencontre-Chapel Island-Random Formations is present (Stops 3A, 4F). The absence of the uppermost Precambrian – lowest Cambrian Rencontre and Chapel Island Formations in the Avalon and Bonavista Peninsulas emphasizes the magnitude of the sub-Random unconformity in these areas of southeastern Newfoundland.

Evidence of the Avalonian unconformity in the Burin and eastern Avalon Peninsula regions is less convincing because of unresolved problems in correlation of uppermost Precambrian and lowest Cambrian sediments. Probable evidence for the Avalonian unconformity in the southwestern Burin Peninsula has been reported by Strong *et al.* (1978, p. 25) who noted a pronounced angular unconformity between the "Inlet Group" (=Chapel Island Formation) and pillow basalts of the much older Burin Group. Possible evidence for folding associated with compressive tectonics during the Avalonian orogeny may be present in the northeastern part of the Avalon Peninsula. The "Lilly unconformity" at Knobby Hill to the north of St. John's (see King, 1982) features an angular unconformity between folded Conception Group strata with conglomerates assigned to the top of the local upper Precambrian (Flat Rock Cove Formation).

UPPERMOST PRECAMBRIAN-CAMBRIAN

Depositional Sequences (EL)

As discussed above, the uppermost Precambrian through Lower Cambrian appears to lie unconformably on the rocks of the Avalonian orogen in southeastern Newfoundland. The oldest rocks of this interval (Rencontre and Chapel Island Formations) occur in the western part of this area (Fortune Bay, Burin Peninsula, eastern Placentia Bay) and, in general, higher units (Random through Brigus Formations) overlie the eroded upper Precambrian in eastern localities (see Landing and Benus, this Bulletin). A generalized easterly sense of cumulative onlap and a westerly-facing regional depositional slope in the latest Precambrian and Early Cambrian differs from the southerly facing paleoslope of the late Precambrian (see King, 1979). The apparent easterly or southerly direction toward the "interior" of the Avalon Platform during the Cambrian also seems to be appropriate to other regions of the North American portion of the Avalon Platform. Landing (In press) has summarized available evidence that suggests that Lower Cambrian onlap took place towards present southerly and easterly directions in eastern Massachusetts, Rhode Island and southern New Brunswick.

The uppermost Precambrian through Lower Cambrian in southeastern Newfoundland is divisible into three unconformity-bounded depositional sequences (e.g. Vail and others, 1977; see Figure 5). The lowest of these is the Rencontre Formation-Chapel Island Formation-Random Formation interval. Conformable relationships are demonstrable between these formations in the southern Burin Peninsula (Stops 2B, 2C, 4F, G) while the lower contact of this stratigraphic package represents the Avalonian unconformity. The feather edge of this depositional sequence lies between Trinity and Conception Bays and within St. Mary's Bay at the eastern limit of the Random Formation. The top of the Random Formation is a regional unconformity surface at all localities with overlying Lower Cambrian units in southeastern Newfoundland (see Landing and Benus, this Bulletin). The second depositional sequence is the unconformity-bounded Bonavista Group in the Trinity-Placentia Bay and eastern Conception Bay and St. Mary's Bay regions (see Landing and Benus, this Bulletin). The Bonavista Group is unconformably overlain by the Brigus Formation (emended) while a condensed manganese nodule bed or manganiferous shales mark the onset of Middle Cambrian deposition (Chamberlain's Brook Formation) following a regional hiatus in the Lower-Middle Cambrian boundary interval (see Hutchinson, 1962; Fletcher, 1972).

Lowest depositional sequence

Rencontre Formation (PM, EL).–Conglomeratic red beds of the Rencontre Formation unconformably overlie acidic volcanics on the southwestern tip of the Burin Peninsula (Stop 2A) and mark the onset of latest Precambrian deposition. These proximal alluvial deposits are succeeded by fluvial and marginal marine siliciclastic sandstones, siltstones and mudstones. Depositional environments for the upper part of the formation near the transition into the overlying Chapel Island Formation were probably peritidal (Myrow, 1987). The depositional history of the Rencontre Formation was complex with sedimentation and accumulation strongly controlled by fault activity (Smith and Hiscott, 1984).

The Rencontre Formation crops out on islands in Fortune Bay and in the southwestern Burin Peninsula (O'Brien *et al.*, 1977; Smith and Hiscott, 1984). The formation is recognizable on the south-central coast of the Burin Peninsula at the northern end of Duck Point (EL, PM, and MMA, field data). It is probable that the feather edge of the Rencontre Formation extends into the west-central part of Placentia Bay as a 25 m-thick unit of red, arkosic, conglomeratic sandstone that O'Brien *et al.* (1983) assigned to the base of "unit 7e" of the Marystown Group. The overlying strata of "unit 7e" are reported to be grey and green, fine-grained sandstones with shaley laminae (O'Brien *et al.*, 1977) that may represent the Chapel Island Formation. The seemingly conformable relationship between "unit 7e" and the overlying thin (feather edge) of the Random Formation at Paradise Sound (O'Brien *et al.*, 1977; EL, unpub. data) is very persuasive evidence for recognition of the formations forming the lowest depositional sequence in western Placentia Bay.

Lithostratigraphy of the Chapel Island Formation (PM, EL).-The thickness of the Chapel Island Formation in the southwestern Burin Peninsula is not known with precision. It is at least, but probably not much greater than, 1,000 m thick. The most useful stratigraphic subdivision of the Chapel Island Formation is Bengston and Fletcher's (1983). These authors divided the formation into five informal members, numbered 1-5, based on outcrops at Grand Bank (lower members) and Little Dantzic Cove (upper members). This same scheme was also used without modification by Crimes and Anderson (1985). These informal members have been more clearly defined by Narbonne *et al.* (1987) and are shown in Figures 6-8.

The base of the Chapel Island Formation is most easily defined at Grand Bank Head at the first green interval greater than 1 m-thick in the transition from the underlying redbeds of the Rencontre Formation. This definition follows Potter's (1949) suggestion. Member 1 consists of ca. 180 m of red and green, thin to medium bedded sandstones, siltstones and shales with intervals of laminated black shales and gray shaly siltstones in the upper half of the member.

The contact between member 1 and member 2 is best exposed at Fortune Head where it is placed at the lowest occurrence of the very diagnostic and easily recognizable gray-green siltstone and sandstone beds that characterize most of member 2. Packages of red and green sandstones and shales, similar in character to those in member 1, are present above this base but are included in member 2.

The contact between members 2 and 3 was defined by Bengtson and Fletcher (1983) and Crimes and Anderson (1985) at

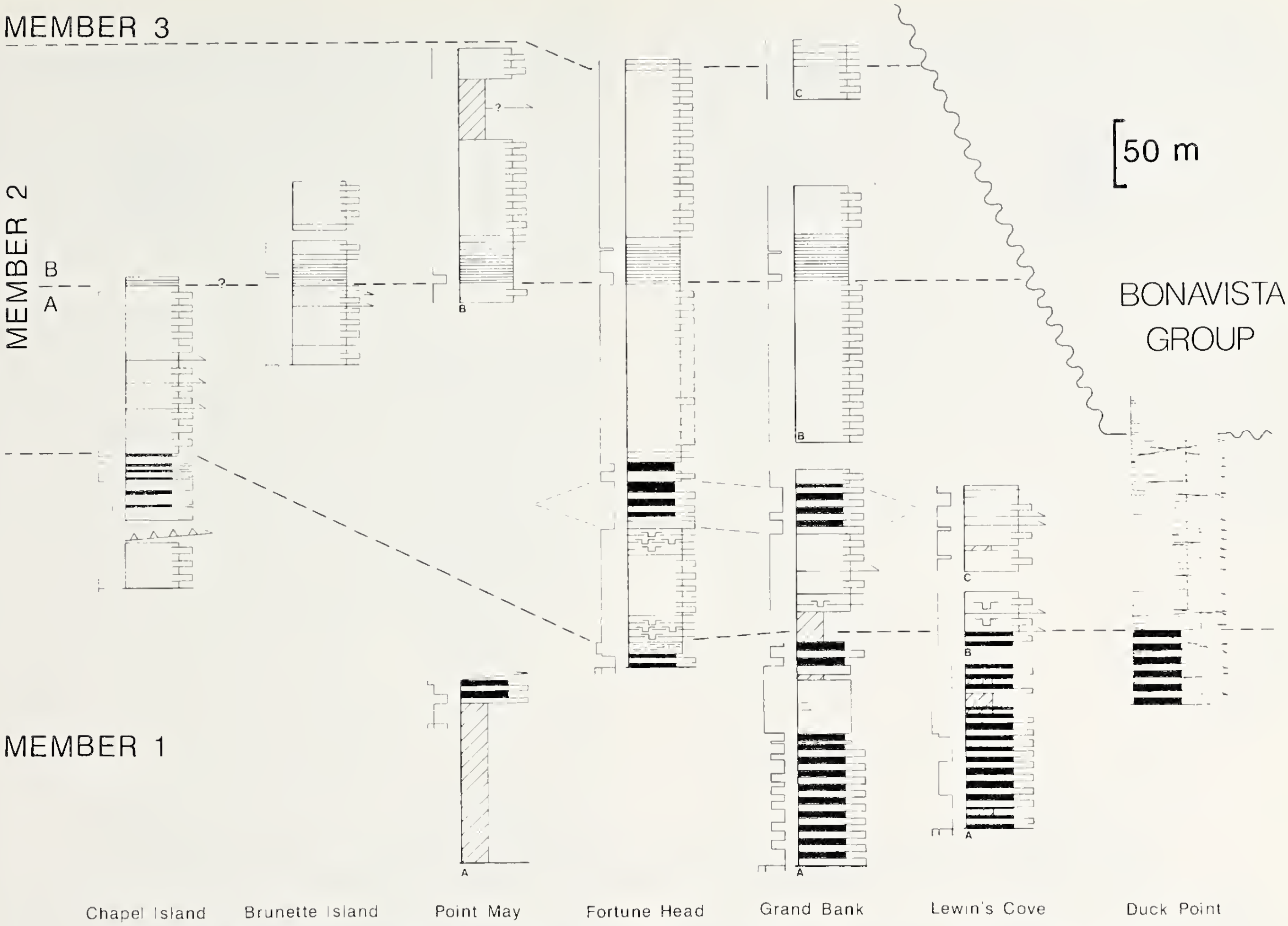


Figure 6. Correlation of the lower part of the Chapel Island Formation, Fortune Bay and southern Burin Peninsula (from Myrow, 1987). See Figure 8 for locations of sections.

the base of a red siltstone unit (Facies 2.3 of this study) at Grand Bank Head. At this locality, the red siltstone is succeeded by several meters of green laminated siltstone (Facies 2.4 of this study) that occur just below the highly faulted part of this section. These earlier reports equated the laminated siltstones with member 3, which is lithologically similar and is found (with its base not exposed) at Little Dantzic Cove. At Fortune Head, however, these red and green siltstones (formerly part of member 3) are succeeded by green sandstones and siltstones of the same facies as that of member 2; this can also be demonstrated at Grand Bank Head by carefully tracing the beds across numerous faults. The lower boundary of member 3 has therefore been moved upward in this report to a point higher in the formation where the sandstones and siltstones grade into the laminated siltstones of member 3. The old boundary between member 2 and member 3, which now lies *within* member 2 as defined herein, is used to separate the member into two parts, 2A and 2B. The thickness of member 2 is approximately 430 m with member 2A being 265 m-thick and with ca. 165 m assigned to member 2B.

The change from member 2 to the carbonate concretion-bearing laminated siltstones of member 3 is gradational. Unfortunately, no outcrop of the Chapel Island Formation preserves a complete section from member 2 to member 4, and the absence of marker beds leaves the exact thickness of member 3 in question. The longest section of member 3 is at Little Dantzig Cove where 135 m of strata have been measured (Stops 4A, B). The total thickness of member 3 is probably not significantly greater than 150 m.

Member 4 consists of red and green bioturbated mudstones, grey pyritiferous mudstones, and thin, nodular to bedded limestones. Stromatolitic build-ups and fossil hash limestones are restricted to this member. The contact between member 3 and member 4 is defined at the top of two meter-scale green to red mudstone cycles in the uppermost part of member 3. At Little Dantzig Cove, a double bed of nodular limestone (microsparite) located 135 m above the base of the measured section lies in the very top of member 3 but does not appear at the top of the second green-red mudstone cycle at the Fortune North section (see Stop 4B). The top of member 4 at all localities in the southwestern part of the Burin Peninsula is a thick limestone bed with prominent algal mud mounds and mud-cracked stromatolitic laminations near its top. The thickness of member 4 at Little Dantzig Cove and the Fortune North sections is 85 m. The estimate of 165 m for a local maximum thickness of member 4 (Bengtson and Fletcher, 1983) was based on an incorrect correlation of a thick nodular limestone bed *within* the middle part of member 3 at Fortune North with the limestone bed at the *top* of member 3 at Little Dantzig Cove (T.P. Fletcher, pers. commun., 1985). This mis-correlation allowed for the measure-

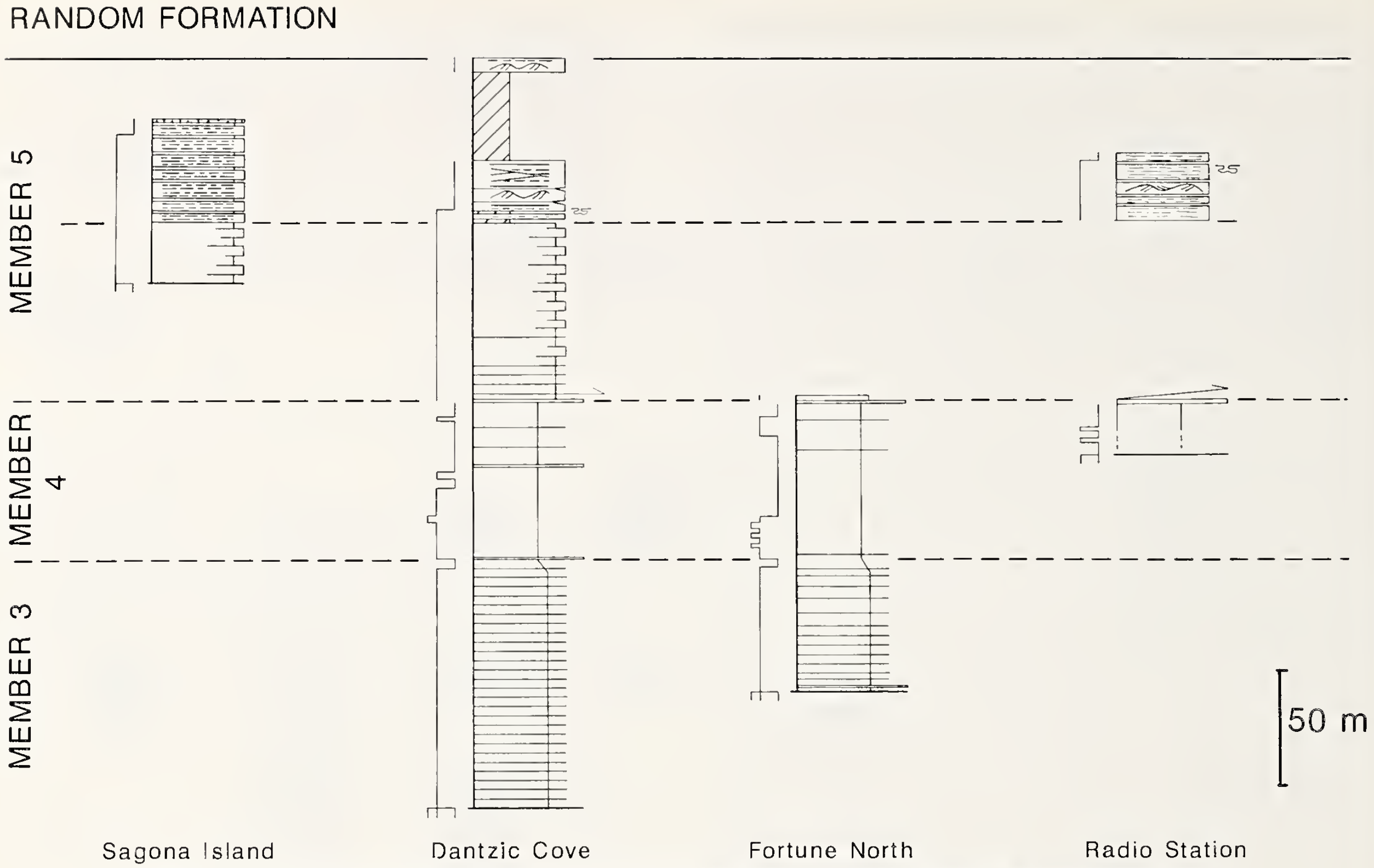


Figure 7. Correlation of the upper part of the Chapel Island Formation, Fortune Bay and southern Burin Peninsula (from Myrow, 1987). See Figure 8 for locations of sections.

ment of a much greater thickness of member 4 at the Fortune North section (Landing *et al.*, In prep.).

Member 5 abruptly overlies the stromatolitic limestone that forms the top of member 4 and consists of green thin- to mediumbedded sandstones and sandy siltstones in its lower part. These siliciclastics show an upward increase in bed thickness and sandstone/siltstone ratio through member 5. This trend continues into the upper part of member 5 where medium- to thick-bedded, red micaceous sandstones are dominant. The thickness of member 5 at Little Dantzig Cove is 178 m.

Depositional environments of the Chapel Island Formation (PM).–The Chapel Island Formation represents a wide variety of shelf environments. The lower two members (Stops 2 and 3) have been divided into four facies associations (Myrow, 1987): 1) red and green sandstones and shales, 2) grey to black, thinly laminated shales and silty shales, 3) thin- to medium-bedded grey-green sandstones and siltstones, and 4) green and red laminated siltstones. The red and green sandstones and shales of Facies Association 1 were deposited in tidally-influenced, nearshore environments. The grey to black shales and silty shales of Facies Association 2 accumulated in semirestricted shoreline environments while the grey-green sandstones and siltstones of Facies Association 3 formed in a muddy deltaic system. Storm-generated sandstones (tempestites) and other storm-related features (e.g., gutter and pot casts) are prominent. Submarine slide and gravity flow deposits in Member 3 attest to conditions of high sediment supply in a delta front/upper prodelta setting. The red and green siltstones of Facies Association 4 form excellent marker horizons and represent delta abandonment facies.

The laminated green siltstones of member 3 (Stop 4A) are interpreted as outer shelf deposits. Sandstone laminae in this facies are interpreted as distal tempestites deposited by waning flows below storm wave base.

The red, green and gray mudstones of Member 4 (Stops 3B-D) accumulated on the inner shelf, while the thin, red fossiliferous algal limestones were deposited in peritidal environments. Deposition took place on a low energy, oxygen-stratified muddy shelf. The peritidal limestone beds formed either during low stands of sea level or during intervals when the rate of sediment accumulation exceeded the rate of sea level rise.

The thin to medium bedded, green sandstones and siltstones in the lower part of Member 5 were deposited on the shelf below storm wave base. The upper part of member 5 (thin to medium bedded, planar laminated and hummocky cross-stratified, red micaceous sandstones and siltstones) was deposited in storm- and wave-dominated inner shelf and shoreface environments.

Random Formation (EL, PM).–The Random Formation is a very significant stratigraphic unit in the Lower Cambrian of southeastern Newfoundland. The prominent quartz arenites of the Random record an influx of quartz sands within the sub-trilobitic Lower Cambrian of this region. Landing (In press) has suggested that the Random Formation is the local representative of a high-energy, quartz arenite facies that was regionally extensive on the Avalon Platform. Local names that have been applied to this lithosome in various Avalon Platform regions include the Wrekin Quartzite (England), Random Formation (= Blue Pinion Formation) (Newfoundland), "unnamed quartzite" in the Little Hollow Formation (mainland Nova Scotia), "beds 5-8" of the Morrison River Formation (Cape Breton Island), "White Quartzite" of the Glen Falls Quartzite (New Brunswick); North Attleboro Formation (Massachusetts). In these regions, this white quartzite lithosome is unconformably overlain by sub-trilobitic Lower Cambrian or higher strata (see Landing and Benus, this Bulletin).

The Random Formation conformably overlies the Chapel Island Formation in the Fortune Bay area (Anderson, 1981; Hiscott, 1982; Myrow, 1987). The sections on the southwest part of the Burin Peninsula indicate a gradual transition from the storm- and wave-influenced environments of member 5 of the Chapel Island Formation to one in which strong tidal currents vigorously reworked nearshore sediments. On the Burin Peninsula, the upper two-thirds of the Random Formation consists of trough cross-bedded and herringbone cross-bedded quartz arenites and minor shales. These represent deposition under macrotidal conditions in shallow subtidal and lower intertidal environments (Myrow, 1987).

Biota (EL).—Trace fossils and skeletalized metazoans appear in the first depositional sequence above the Avalonian orogen in southeastern Newfoundland. Although no fossils are presently known in the Rencontre Formation, late Precambrian-aspect trace fossils of the *Harlaniella podolica* Zone appear in member 1 and persist into the lower 2.4 m of member 2 of the Chapel Island Formation. This low diversity assemblage of sub-horizontal grazing traces is rapidly replaced by feeding and deep dwelling burrows of the *Phycodes pedum* Zone in lower member 2 (Stop 3B). This second assemblage provides a practical and correlatable base of the Cambrian System (Narbonne *et al.*, 1987). All species of the *Phycodes pedum* Zone persist through the upper part of the Chapel Island Formation and into the Random Formation. However, arthropod traces (*Rusophycus*, *Dimorphichnus*) and burrows with *spreiten* appear in the lower part of member 2 and are used to define the stratigraphically long ranging (through the Random Formation) *Rusophycus avalonensis* Zone.

Skeletal fossils occur through much of the Chapel Island Formation although these remains are not preserved in the coarse-grained facies of member 5 or the Random Formation. Organic-walled tubes of *Sabellidites cambriensis* occur in upper member 1 and lower member 2 of the Chapel Island and are locally abundant in the Precambrian-Cambrian boundary interval (Stop 3A). Despite thorough searching of outcrop surfaces and acid-disaggregation of carbonate nodules, no additional skeletalized fossil remains were recovered through much of member 2. However, a few poorly preserved conchs of the problematical metazoan "*Ladatheca*" *cylindrica* (Grabau) were recovered near the top of member 2B (ca. 390 m) at the Fortune Head section (Stop 3F). A somewhat more diverse small shelly fossil assemblage appears in the siliciclastic mudstones of upper member 3 with the association of "*L.*" *cylindrica*, *Aldanella attleborensis* (Shaler and Foerste), and *Watsonella crosbyi* Grabau appearing 41.25 m below the base of member 4 at Fortune North. This assemblage persists through member 4 where it is accompanied by halkierids, and species of *Lapworthella*, *Fomitchella*, *Tiksitheca*, *Cambrotubulus* and *Coleoloides* and orthothecids in the bedded limestones of member 4. (Stops 4A-D). The lowest occurrence of *A. attleborensis* is used to define the base of the "lower *Aldanella attleborensis* Interval" in the Chapel Island Formation while the underlying interval from upper member 2B through most of member 3 is the "*Ladatheca*" *cylindrica* Interval" (Landing, In press). Neither of these faunal intervals should be regarded as having a practical biostratigraphic significance within the Chapel Island Formation. Indeed early diagenetic dissolution of small shelly fossils in the somewhat lighter green colored shales at the Little Dantzic Cove section seems to be responsible for the loss of almost all small shelly fossils (with the exception of "*L.*" *cylindrica*) from upper member 3 and lower member 4. These remains are preserved as pyrite casts through the upper 41.25 m of member 3 at Fortune North in darker-colored shales. The present report extends the stratigraphic range of small shelly fossils well below their lowest occurrence as reported by Bengtson and Fletcher (1983) from member 4 of the Chapel Island Formation.

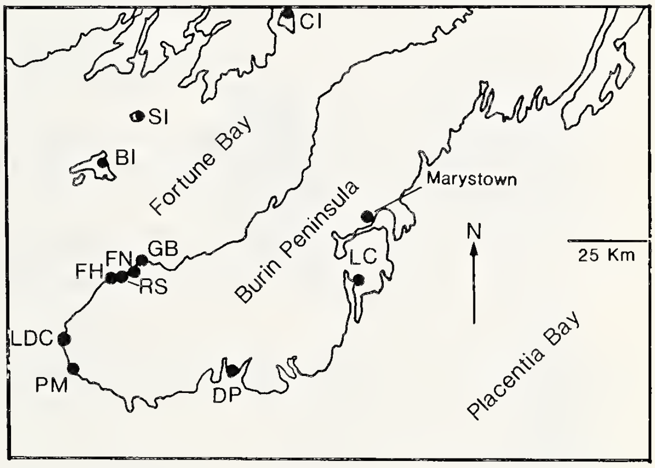


Figure 8. Location of sections in the Chapel Island Formation (see Figures 6, 7), Fortune Bay and Burin Peninsula, southeastern Newfoundland. Abbreviations: BI, Brunette Island; CI, Chapel Island; DP, Duck Point; FH, Fortune Head (Stop 3); FN, Fortune North; GB, Grand Bank and Grand Bank Head (Stop 2); LC, Lewin's Cove; LDC, Little Dantzic Cove (Stop 4); PM, Point May; RS, "Radio Station;" SI, Sagona Island.

Lower Cambrian depositional sequences (EL)

The upper part of the sub-trilobitic Lower Cambrian (= Bonavista Group) and the trilobitic Lower Cambrian (= Brigus Formation) are both unconformity-bounded depositional sequences. An emended stratigraphic scheme for the Bonavista Group is provided by Landing and Benus (this Bulletin) and the nature of the regional unconformities separating the Bonavista Group from lower strata (Random Formation and older units) and from the overlying Brigus Formation are discussed by those authors. In addition, Landing and Benus (this Bulletin) apply the small shelly fossil biostratigraphic scheme of a "upper *Aldanella attleborensis* Interval" and a superjacent "*Camenella baltica* Interval" which has been proposed for the sub-trilobitic Lower Cambrian of eastern Massachusetts (Landing, In press) to the Bonavista Group. These "intervals" are characterized by faunal assemblages which are roughly equivalent to Bengtson and Fletcher's (1983) "*Aldanella attleborensis* assemblage" and "*Coleoloides typicalis* assemblage."

ACKNOWLEDGMENTS

EL and APB gratefully acknowledge field support from the National Geographic Society (grants 2453-82 and 2619-83) and field and laboratory assistance from National Science Foundation grant EAR83-12939. GMN received support from the Natural Sciences and Engineering Council (N.S.E.R.C. Grant A2648).

REFERENCES CITED

Anderson, M.M. 1978. Ediacaran fauna, pp. 146-149. *In* Yearbook of Science and Technology. *Edited by* D. N. Lapedes. McGrawHill Book Co., New York.

________ 1981. The Random Formation of southeastern Newfoundland: A discussion aimed at establishing its age and relationship to bounding formations. Amer. J. Sci. 281:807-830.

________ 1987. Late Precambrian Conception Group glacigenic sequence (Gaskiers Formation) at Double Road Point, St. Mary's Bay, southeastern Newfoundland. Geol. Soc. Amer., Decade of North American Geology Field Guide 5.

________ and Conway Morris, S. 1982. A review, with descriptions of four unusual forms, of the soft-bodied fauna of the Conception and St. John's Groups (late Precambrian), Avalon Peninsula, Proc. 3rd North Amer. Paleo. Conv., Montreal, 1:1-8.

________ and Misra, S. B. 1968. Fossils found in pre-Cambrian Conception Group of southeastern Newfoundland. Nature 220:680-681.

Bengtson, S. and Fletcher, T. P. 1983. The oldest sequence of skeletal fossils in the Lower Cambrian of southeastern Newfoundland. Canadian J. Earth Sci. 20:525-536.

Benus, A. P. and Landing, E. 1984. Depositional environments of the Bonavista Formation (Early Cambrian, eastern Newfoundland). Geol. Soc. Amer. Abstr. Prog. 16:3.

Brückner, D. 1977. Significance of new tillite finds for eastwest correlation of Proterozoic Avalon-zone formations in southeastern Newfoundland. Estud. geol. Inst. 'Lucas Mallada' 33:357-364.

Cloud, P. and Glaessner, M. F. 1982. The Ediacaran Period and System: Metazoa inherit the earth. Sci. 217:783-792.

Crimes, T. P. 1987. Trace fossils and correlation of late Precambrian and Early Cambrian strata. Geol. Mag. 124:97119.

________ and Anderson, M. M. Trace fossils from late Precambrian-Early Cambrian strata of southeastern Newfoundland (Canada): Temporal and environmental implications. J. Paleo. 59:310343.

Dale, N. C. 1927. Pre-Cambrian and Paleozoic geology of Fortune Bay, Newfoundland. Geol. Soc. Amer. Bull. 38:411-430.

Fletcher, T. P. 1972. Geology and Lower to Middle Cambrian trilobite faunas of southwest Avalon, Newfoundland. Unpub. Ph.D. diss., University of Cambridge, U. K., 472 p.

Hofmann, H. J., Hill, J., and King, A. F. 1979. Late Precambrian microfossils, southeastern Newfoundland. Geol. Surv. Canada Pap. 79 1B:83-98.

Hutchinson, R. D. 1957. Geology of the Harbour Grace Map-area, Newfoundland. Geol. Surv. Canada Mem. 275, 43 p.

________ 1962. Cambrian Stratigraphy and trilobite faunas of southeastern Newfoundland. Geol. Surv. Canada Bull. 88, 156 p.

Jenness, S. E. 1963. Terra Nova and Bonavista Map-areas, Newfoundland. Geol. Surv. Canada Mem. 327, 184 p.

Keppie, J. D. 1982. Geology and tectonics of Nova Scotia, pp. 125-139. *In* Guidebook for Avalon and Meguma Zones. *Edited by* A. F. King. The Caledonide Orogen, IGCP Project 27, NATO Advanced Study Institute, Atlantic Canada, August, 1982, Pub. No. 50, St. John's, 308 p.

King, A. F. 1979. The birth of the Caledonides: Late Precambrian rocks of the Avalon Peninsula, Newfoundland, and their correlatives in the Appalachian-orogen, pp. 3-9. *In* The Caledonides in the USA. *Edited by* D. R. Wones. Int. Geol. Corr. Prog. Project 27, 1979 mtg., Blacksburg, Va., Virginia Poly. Inst. State Univ., Mem. 3, 289 p.

________ 1982. Stop 0-3: Flat Rock thrust, tillite and the Lilly unconformity, pp. 37-41. *In* Guidebook for Avalon and Meguma Zones. *Edited by* A. F. King. The Caledonide orogen. Int. Geol. Corr. Proj. 27, NATO Adv. Study Inst., Atlantic Canada, August, 1982, Pub. No. 50, St. John's, 308 p.

________ 1986. Geology of the St. John's area, Newfoundland. Current Res. Nfld. Dept. Mines Energy Rep. 86-1:209-218.

Krogh, T.E., Strong, D.F., O'Brien, S.J., and Papezik, V.S. In press. Precise U-Pb zircon dates from the Avalon terrane in Newfoundland. Canadian Jour. Earth Sci.

Lilly, H. D. 1966. Late Precambrian and Appalachian tectonics in the light of submarine exploration of the Great Bank of Newfoundland and in the Gulf of St. Lawrence, Preliminary views. Amer. J. Sci. 264:569-574.

Landing, E. In press. Lower Cambrian of eastern Massachusetts: Stratigraphy and small shelly fossils. J. Paleont.

________ and Benus, A. P. 1984. Lithofacies belts of the Smith Point Limestone (Lower Cambrian, eastern Newfoundland) and the lowest occurrence of trilobites. Geol. Soc. Amer. Abst. Prog. 16:45.

________, Myrow, P. and Narbonne, G. M. In prep. Diagenetic and environmental control on the occurrence of the oldest skeletal fossils, Lower Cambrian, southeastern Newfoundland.

McCartney, W. D. 1957. Dildo, Newfoundland. Geol. Surv. Canada Map 13-1956.

________ 1969. Geology of Avalon Peninsula, southeast Newfoundland, pp. 115-129. *In* North Atlantic—Geology and Continental Drift. *Edited by* M. Kay. Amer. Assoc. Petrol. Geol. Mem. 12, 1,082 p.

Misra, S. B. 1969a. Geology of Biscay Bay-Cape Race area, Avalon Peninsula, Newfoundland. Unpub. M.Sc. thesis, Memorial Univ., St. John's, Nfld., 139 p.

________ 1969b. Late Precambrian(?) fossils from southeastern Newfoundland. Geol. Soc. Amer. Bull. 80:2133-2140.

________ 1981. Depositional environment of the late Precambrian fossil-bearing rocks of southeastern Newfoundland, Canada. J. Geol. Soc. India 22:375-382.

Myrow, P. M. 1987. Sedimentology and depositional history of the Chapel Island Formation (late Precambrian to Early Cambrian) southeast Newfoundland. Unpub. Ph.D. diss., Memorial Univ. Nfld., St. John's, 509 p.

Narbonne, G. M., Myrow, P., Landing, E., and M. M. Anderson. 1987. A candidate stratotype for the Precambrian-Cambrian boundary, Fortune Head, Burin Peninsula, southeastern Newfoundland. Canadian J. Earth Sci. 24:1277-1293

O'Brien, S. and King, A. F. 1982. The Avalon Zone in Newfoundland, pp. 1-27. *In* Guidebook for Avalon and Meyuma Zones. *Edited by* King, A. F. The Caledonide Orogen, IGCP Project 27, NATO Advanced Study Institute, Atlantic Canada, August, 1982, Pub. No. 50, St. John's, 308 p.

________, Strong, P. G. and Evans, J. L. 1977. The geology of the Grand Bank (1M/4) and Lamaline (1L/13) map areas, Burin Peninsula, Newfoundland. Min. Dev. Div., Dept. Mines Energy, Govt. Nfld. Labrador, Rept. 77-7, 16 p.

________ and TAYLOR, S. W. 1983. Geology of the Baine Harbour (1M/7) and Point Enragee (1M/6) map areas, southeastern Newfoundland. Min. Dev. Div., Dept. Mines Energy, Govt. Nfld. Labrador, Rept. 83-5, 70 p.

Potter, D. B. 1949. Geology of the Fortune-Grand Bank area, Burin Peninsula, Newfoundland, Canada. Unpub. M.Sc. thesis, Brown Univ., Providence, R.I., 50 p.

Rast, N., O'Brien, B. H. and Wardle, R. J. 1976. Relationships between Precambrian and Lower Paleozoic rocks of the 'Avalon Platform' in New Brunswick, the northeast Appalachians and the British Isles. Tectonophys. 30:315-338.

Seilacher, A. 1967. Bathymetry of trace fossils. Mar. Geol. 5:413-420.

Smith, S. A. and Hiscott, R. N. 1984. Latest Precambrian to Early Cambrian basin evolution, Fortune Bay, Newfoundland: Fault-bounded basin to platform. Canadian J. Earth Sci. 21:1379-1392.

Sokolov, B. S. and Fedonkin, M. A. 1984. The Vendian as the terminal System of the Precambrian. Episodes 7:12-19.

Strong, D. F. 1979. Proterozoic tectonics of northwestern Gondwanaland: New evidence from southeastern Newfoundland. Tectonophys. 54:81-101.

________, O'Brien, S. J., Taylor, S. W., Strong, P. G. and Wilton, D. H. 1978. Geology of Marystown (1M/3) and St. Lawrence (1L/14) map areas, Newfoundland. Min. Dev. Div., Dept. Mines Energy, Govt. Nfld. Labrador, Rept. 77-8, 81 p.

Vail, P. R., Mitchum, R. M., and Thompson III, S. 1977. Seismic stratigraphy and global changes of sea level, Part 3: Relative changes of sea level from coastal onlap, pp. 63-81. *In* Seismic Stratigraphy–Applications to Hydrocarbon Exploration. *Edited by* Payton, E. Amer. Assoc. Petrol. Geol. Mem. 26, 720 p.

Williams, H., Kennedy, M. J., and Neale, E. R. W. 1974. The northeastward termination of the Appalachian orogen, pp. 79123, Vol. 2. *In* The Ocean Basins and Margins. *Edited by* Nairn, A. E. M. and Stehli, F. G. Plenum Press, New York, 637 p.

________ and King, A. F. 1979. Trepassey map area, Newfoundland. Geol. Surv. Canada, Mem. 389, 24 p.

Field trip road log

DAY 1

Kilometers

0.0 Depart from Memorial University, turn onto Route 10 (south) in the southeastern part of St. John's and continue on Rte. 10 around the eastern and southern margins of the Avalon Peninsula. The route to Bay Bulls leads over low, rolling terrane underlain by shales of the St. John's Group. A prominent ridge to the east consists of sandstones and conglomerates of the Signal Hill Group (MMA).

14.5 Village of Bay Bulls. The route south to Ferryland crosses folded and locally faulted strata of the St. John's and Conception Groups. Two major headlands and several islands in the Witless Bay–Mobile Bay–Tor's Cove area consists of red and green sandstones of the Signal Hill Group (MMA).

72.0 Roadcut on west side of Rte. 10 on the south side of the Village of Ferryland.

Stop 1A Ferryland (MMA)

Numerous examples of the pseudofossil *Aspidella terranovica* Billings, 1872, are present on bedding surfaces of steeply eastdipping shales of the St. John's Group. These shales also show lenticular current ripples.

72.1 Continue south on Rte. 10 toward Portugal Cove South. The road runs approximately along the strike of folded beds of the Conception Group and, near Cappahayden, shales of the St. John's Group. The conspicuous hills visible to the west from Aquaforte to beyond Cappahayden are underlain by Harbour Main Group volcanics and, locally, by granitic rocks of the Holyrood plutonic series (MMA).

130.0 Center of Village of Portugal Cove South. Turn east at the junction with Cape Race Road and continue southeasterly along the shore of Trepassey Bay.

133.5 Park on road side and walk to nearby, southerly-dipping shore outcrops of the Drook Formation. The locality is ca. 0.75 km northwest of the large stream valley at the old hamlet of Drook.

Stop 1B Soft-bodied metazoans of the Drook Formation (APB, MMA)

The locality consists of gently dipping beds in the upper part of the Drook Formation (Williams and King, 1979). A large bedding surface has been exposed by erosion of a light-green, highly cleaved tuff. This bedding surface has numerous large specimens (to 25 cm × 15 cm) of the metazoan referred to as a "medusoid" (Figure 9). This surface and two surfaces at Stop 1C in the Mistaken Point Formation (MpMp-11.37 m, -12.11) feature the preservation of soft-bodied metazoans at the base of a fine-grained tuff (Figures 10A-C).

At the end of the stop, continue southeasterly along Cape Race Road.

141.0 Intersection of one-lane gravel track on south side of Cape Race Road, turn right (south) and proceed a short distance before parking. Walk south for ca. 2.5 km to Mistaken Point.

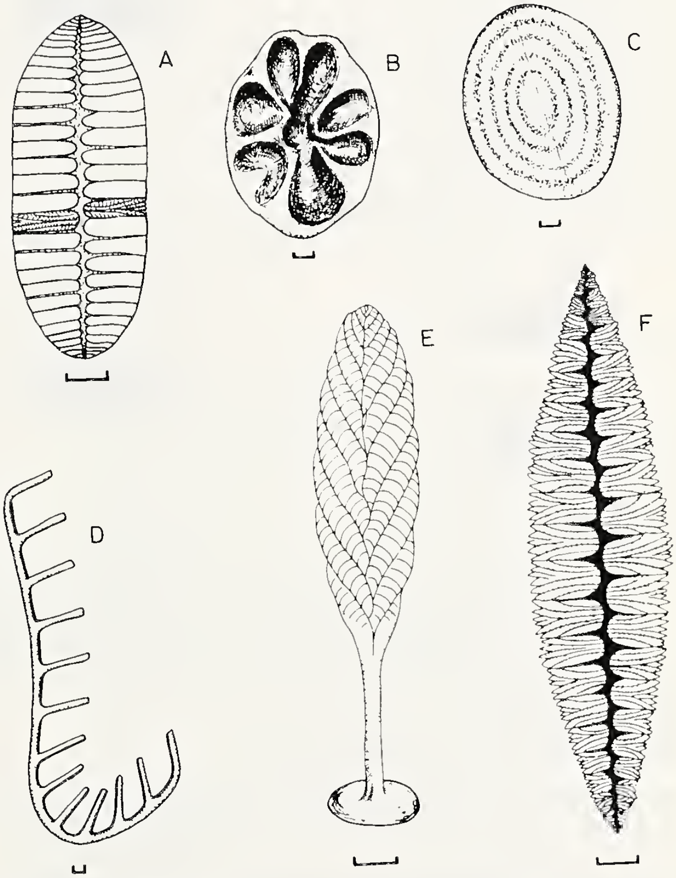


Figure 9. Upper Precambrian soft-bodied metazoans from the Conception Group (bar scale represents 1 cm). A, Spindle-shaped form with false rim (a preservational artifact). B, "Medusoid." C, Disc-like form with concentric annulations. D, Pectinate form. E, *Charnia masoni* Ford, 1958. F, Spindle-shaped form. Forms C and E are rare in the Mistaken Point Formation but common in the Trepassey Formation. Modified from King and Williams (1979, Fig. 14).

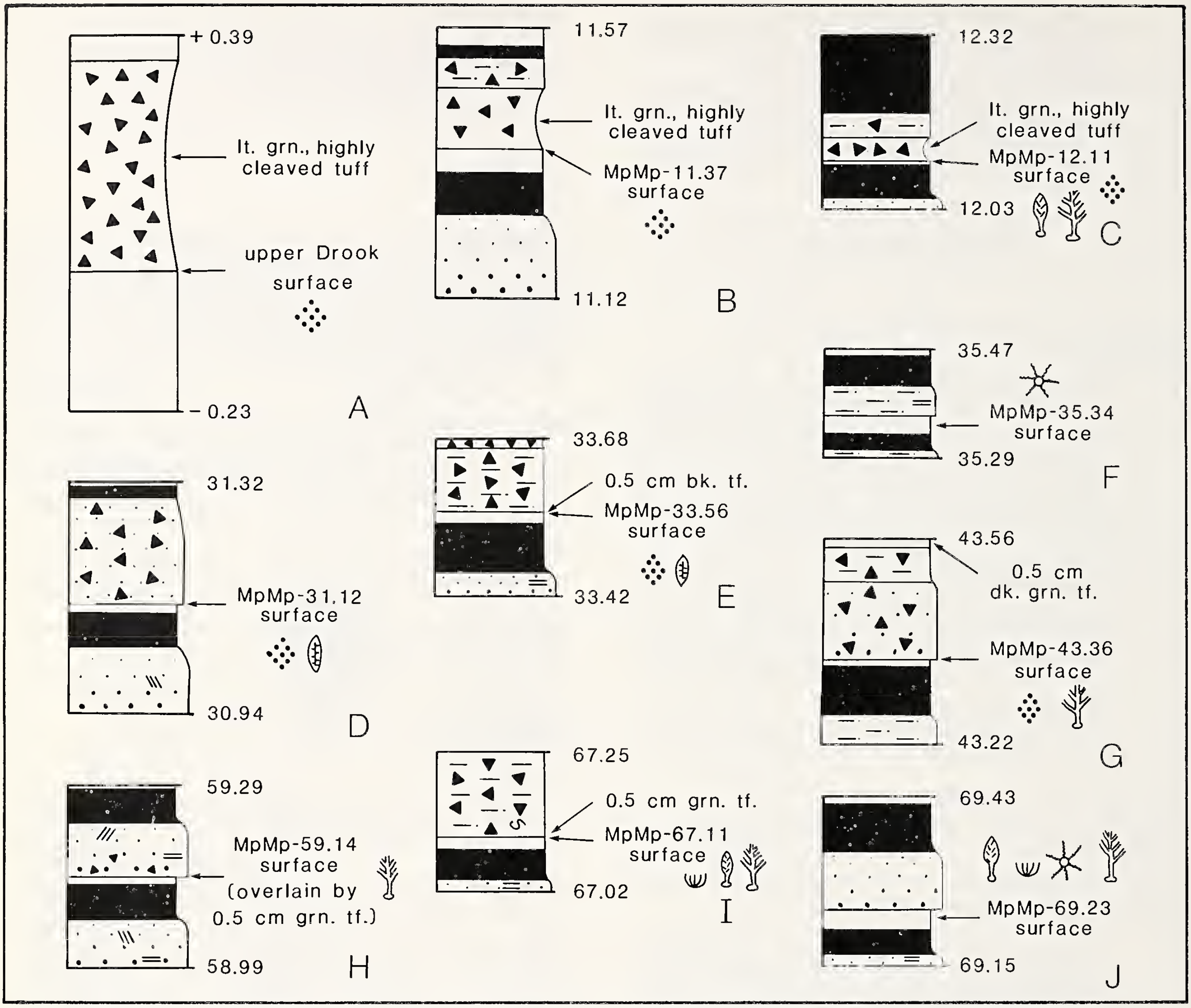


Figure 10. Fossil assemblages and lithologic associations in the Conception Group, southeastern Newfoundland. A, Short section in the upper part of the Drook Formation (Stop 1B). B-J, Nine fossiliferous surfaces (MpMp-11.37 m etc.) known from the Mistaken Point Formation at Mistaken Point. See Figure 11A for explanation of lithology and fossil symbols and for location of these detailed intervals in the measured section.

Stop 1C Mistaken Point (APB, MMA)

Setting (MMA).—Mistaken Point is a prominent, southeasterly trending headland located 7.5 km southwest of Cape Race at the southeastern corner of the Avalon Peninsula. The headland is bounded on its northern side by a fault and is underlain by strata of the uppermost part of the Conception Group. These strata form part of the eastern flank of a broad anticline which plunges gently to the southwest in the vicinity of Drook. The strata strike N30°E and dip 15° to the southeast.

Stratigraphic nomenclature (APB).—The continuously exposed, 120 m-thick section (Figures 11A, B) consists of the uppermost part of the ca. 400 m-thick Mistaken Point Formation (Williams and King, 1979; = "Cape Cove Formation" of Misra, 1969a) and overlying, somewhat thinner-bedded strata of the Trepassey Formation. At this locality and elsewhere in the region, the contact between these units is extremely gradational. Williams and King (1979) defined the Mistaken Point–Trepassey formational boundary as the contact between purple (lower) and green (upper) turbiditic mudstones. However, this color change may be completely diagenetic in origin and may be impractical in definition of a boundary. Similar diagenetic color changes are seen in Lower Cambrian strata of southeastern Newfoundland where green shales can pass laterally into red shales. In addition, several purple-to-green color changes are present within the section and lie at approximately 57 m and 80 m.

Lithology (MMA).–The sequence is a monotonous series of beds that grade internally from arkosic litharenite (lower part) to silicified mudstone (upper part). Thin, light green and, more rarely, pink and white tuffs form cm-thick beds. The graded beds range from less than 5 cm to more than 60 cm in thickness and show considerable variations in the proportion of sandstone and mudstone. Sedimentary structures include grading, horizontal lamination, current ripples, convolute bedding, and, infrequently, rip-up clasts. All or only some of these sedimentary structures are represented in any given bed. Convolute bedding at one stratigraphic level in the Mistaken Point Formation exhibits considerable lateral continuity and has been traced for 8 km to the northeast. Load casts are present at the base of some beds but are not common in the sequence. Sandstone dikes are rare in the Mistaken Point Formation. However, a number of them are present in the lower part of the overlying Trepassey Formation. The graded beds are interpreted as turbidites laid down in a deep-water environment in a northeast-trending turbidite basin (Misra, 1981).

A northeast-trending cleavage is poorly developed in the sequence but is more strongly defined in the tuffaceous litharenites. Pseudoripple marks, identified in some reports as wave ripples (e.g. Williams and King, 1979), are well developed on a number of the fossil-bearing surfaces and owe their origin to movement on a number of curving cleavage planes. This slip cleavage has elongated many of the fossils parallel to the cleavage and shortened them transverse to the cleavage.

Lithofacies Associations (APB).–The Mistaken Point Formation is composed of two dominant lithofacies associations distinguished on the basis of bedding thickness, grain size and Bouma structure: A) interbedded medium to thick turbidites and thin hemipelagic mudstone layers (sandstone/mudstone ratios greater than 1.0) and B) interbedded thin to medium turbidites and hemipelagic layers (sandstone/mudstone ratios less than or equal to 1.0). Turbidites of the former (Association A) consist of medium- to fine-grained arkoses/feldspathic litharenites (Ta-Td divisions) overlain by structureless mudstone (Te). The local amalgamation of up to four such turbidites has produced massive sandstone beds with mudstone rip-up clasts (see 39.0 m- to 39.5 m-interval, Figure 11A). Thin to medium turbidites (Association B) consist of relatively finer-grained arenites (Ta or Tc-d divisions) overlain by structureless mudstones. Turbidites of Association A more frequently show complete Ta-to-Te sequences than Association B (see Figures 11A, B; intervals 46.0-49.5 m and 23-28 m for examples of Association A and B, respectively).

Well defined, thin (ca. 1-2 cm), hemipelagic mudstone layers cap most of the turbidites. These layers are characterized by mm-scale, discontinuous laminae and often contain mm- to cm-thick tuffs and fossils of soft-bodied metazoans on a number of the bedding surfaces. The lower contact of these hemipelagic mudstones with underlying structureless turbiditic mudstones is very sharp. The absence of any bioturbation in these sediments favored the preservation of these contacts.

Depositional environment (APB).–Facies Associations A and B represent the end members of a facies continuum that was deposited in lobe and lobe fringe environments, respectively, of a deep-water outer fan. This mud-rich (high efficiency) fan was adjacent to a volcanic source that contributed thin ashes to the sequence. The relatively distal depositional setting is demonstrated by the turbidite structure and fine grain size, the sheet-like nature of the beds, the lack of channels, and rarity of soft-sediment deformation. The metazoans which lived in this deep water environment are preserved on bedding planes within hemipelagic layers, below tuffs, and below tuffaceous sediment (Figures 10B-J).

A southeasterly-facing slope and transport direction is indicated by cross-laminae in the turbidites and is further corroborated by clastic dike orientations in the upper part of the sequence (Figure 12A and 12B). Interestingly, current directions measured on the "shafts" and "stalks" of attached metazoans and on spindle-like forms (Figure 9) show a northeasterly sense of current transport (Figures 12C-I) This direction is perpendicular to the paleoslope and suggests that the gentle currents responsible for transporting the fine-grained tuffaceous sediment that buried the metazoans were contour currents. The more competent turbidity currents probably uprooted and transported the metazoans away from this habitat.

Fossils (MMA).–The Mistaken Point fauna was first discovered in 1967 (Anderson and Misra, 1968) and has been described, at least in terms of a shape taxonomy (Figure 9) by Misra (1969) and Anderson (1978). Anderson and Conway Morris (1982) reported on four unusual forms. The lack of size sorting of the animals, presence of forms with attachment discs, entombment in very fine-grained deposits that probably reflect currents lacking the competancy to transport the animals, perfect preservation of delicate forms, and lack of current-induced kinks in elongate forms (see A.P. Benus, Abstract, this Bulletin) all suggest that the fossil horizons may be *in situ* death assemblages.

Return to the vehicles at end of stop and return to Portugal Cove South.

152 Portugal Cove South, turn left at intersection and continue toward the Village of Trepassey on Rte. 10. The road crosses strata of the Conception and St. John's Groups. The units are folded into a broad north-northeast trending syncline with a southerly plunge that is visible in the cliffs of Cape Mutton to the south.

164 Trepassey. The road to St. Vincent's and on to Gaskiers traverses folded and faulted rocks of the Conception Group. Geomorphic features of note include the fjords of Trepassey Harbour and Holyrood Pond, a major north-northeast striking fault scarp east of Peter's River, and the barren plateau between Trepassey and Peter's River.

201 Village of St. Vincent's, continue north on Rte. 90 to Gaskiers

Stop 1D Gaskiers Formation (MMA)

The outcrop on the east and west sides of the wharf is the type section of the Gaskiers Formation, a unit consisting entirely of sediments of glacial origin (Anderson, 1987). The uppermost part of the section is made up of massive, reddish-purple diamictites overlain by a bed of red mudstone (less than 1 m-thick) with dropstones in its lower part. Sediments of the Drook Formation conformably overlie the mudstone bed.

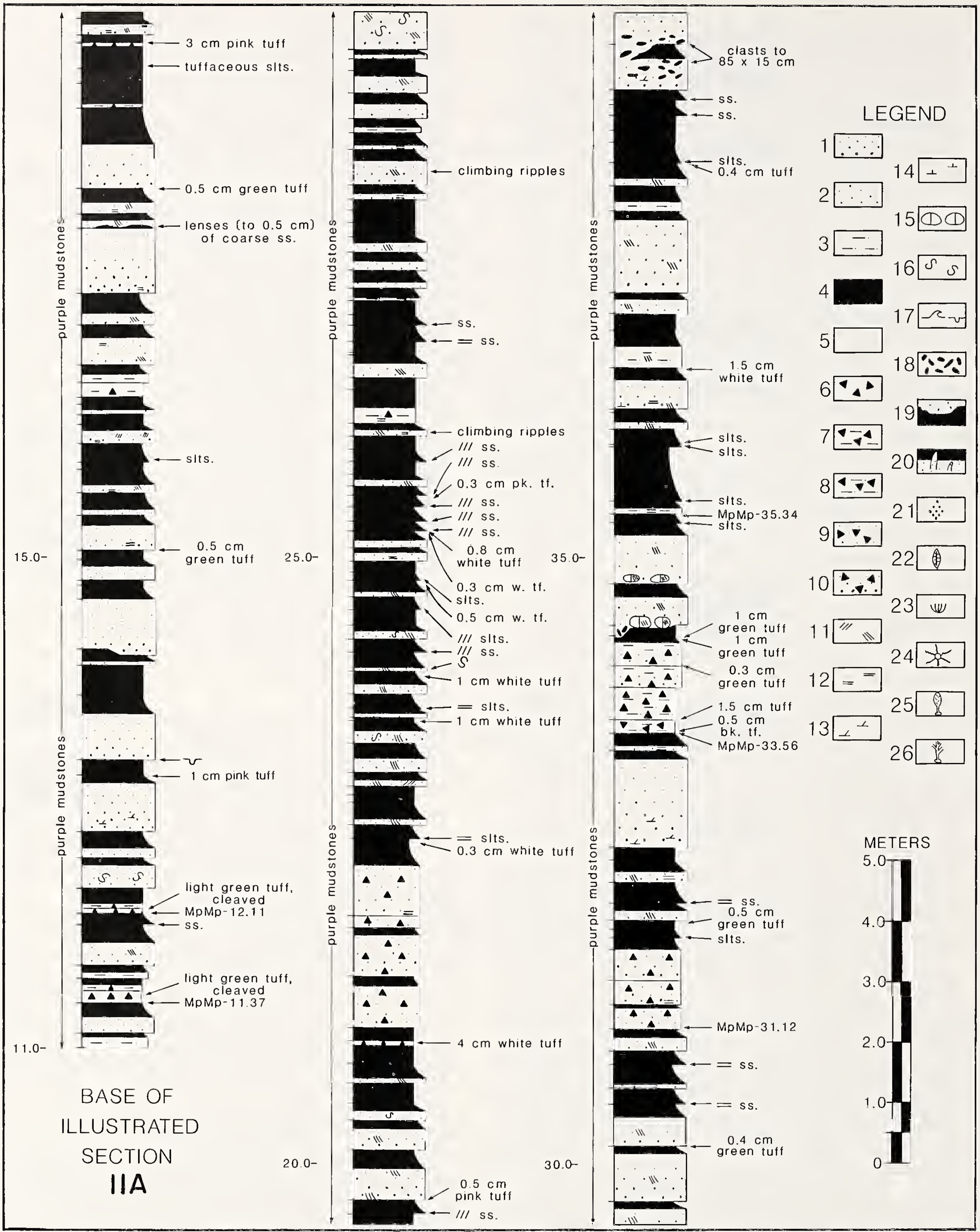


Figure 11A. Lower part of the type section of the Mistaken Point Formation at Mistaken Point. Short "tick" marks on left side of columns indicate bases of depositional units. Legend: 1, Graded sandstone, medium or fine sand grades upward into fine sand or silt, sandstones are lithic arkoses or feldspathic

litharenites; 2, non-graded sandstone, lithology as 1; 3, siltstone; 4, siliceous mudstone [= undifferentiated turbiditic mudstone and hemipelagic mudstone in Figure 11A, B; structureless turbiditic mudstone in Figures 10]; 5, laminated hemipelagic mudstone in Figure 10; 6, tuff; 7, tuffaceous mudstone; 8, tuffaceous siltstone; 9, tuffaceous nongraded sandstone; 10, tuffaceous graded sandstone; 11, cross lamination; 12, parallel lamination; 13, dolomitic; 14, calcareous; 15, calcareous nodules; 16, convolute lamination; 17, flame (left) and load (right) structures; 18, siliceous mudstone rip-up clasts; 19, erosive contacts; 20, clastic dike; 21, "medusoid;" 22, spindle-shaped form; 23, bush-like form; 24, star-shaped form (central attachment disc with radiating filaments); 25, *Charnia masoni* Ford; 26, antler-shaped form (may include extremely large, poorly preserved *C. masoni* as well as pectinate forms of Figure 9). Abbreviations on right side of columns: bk. tf. (black tuff), slts. (siltstone) and ss. (sandstone) in mm- to cm-thick bands too thin to depict on column.

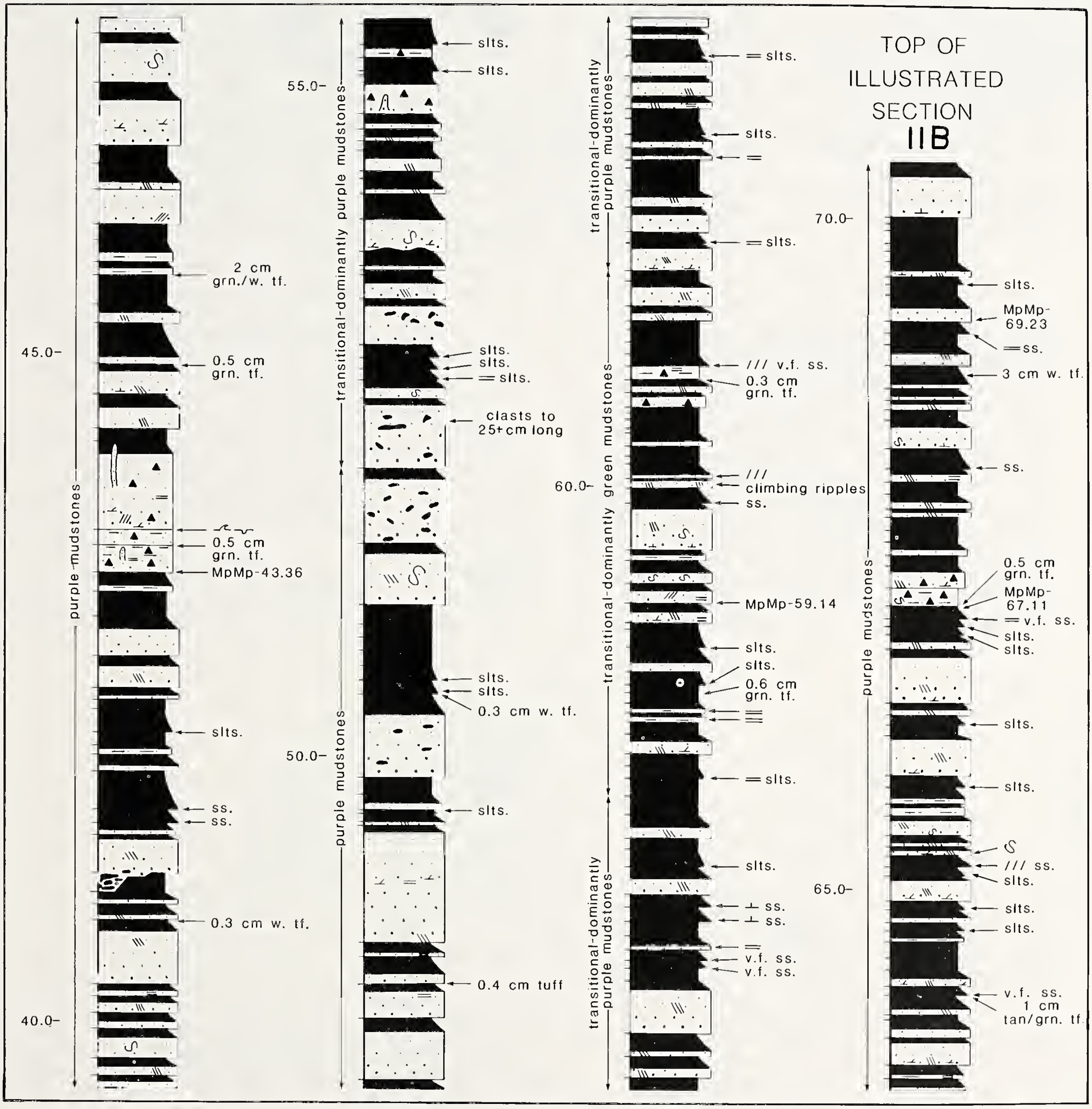


Figure 11B. Upper part of the type section of the Mistaken Point Formation at Mistaken Point. See Figure 11A for explanation.

At the end of this stop, continue on to the Trans-Canada Highway (Rte. 1) via Salmonier Line.

280 Trans Canada, turn left (west).

395 Intersection with Rte. 210 at Goobies, turn left and continue to Marystown.

540 City of Marystown.

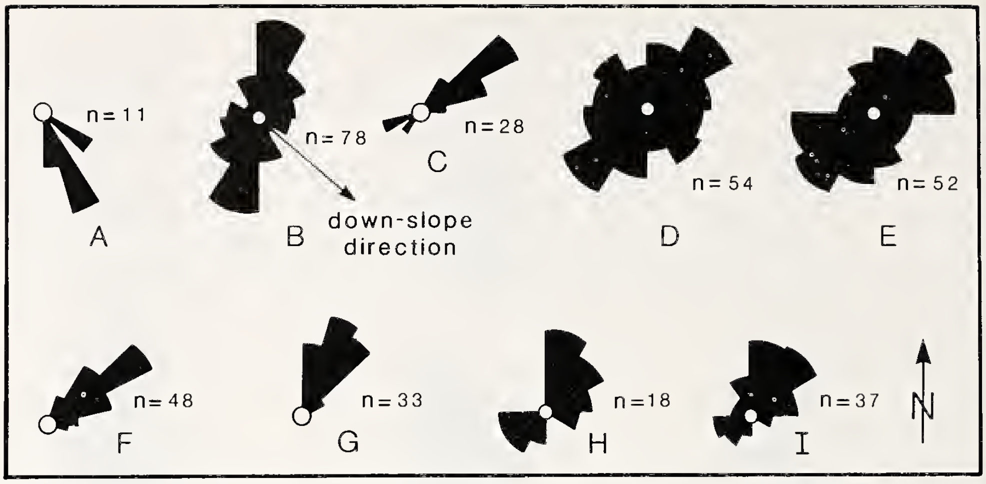


Figure 12. Paleocurrent and -slope determinations in the Mistaken Point Formation at Mistaken Point (Stop 1C). A, Turbidite cross-lamination directions. B, Clastic dike orientation and interpreted paleoslope direction at MpMp-99.65 m. C-I, Current directions based on orientation of elongate fossils on seven bedding surfaces: C, MpMp-12.11 m; D, MpMp-31.12 m; E, MpMp-33.56 m; F, MpMp-43.36 m; G, MpMp-59.14 m; H, MpMp-67.11 m; I, MpMp-69.23 m.

DAY 2

0.0 Depart from hotel and take Rte. 210 west and then Rte. 220 south towards the City of Grand Bank.

53 City of Grand Bank. Take College Street to the northwest side of Admiral Cove and park near the end of the street where it takes a sharp left. A long section through the upper part of the Rencontre Formation, all of member 1 and member 2A, and the lowermost part of member 2B of the Chapel Island Formation will be examined during a walk around Grand Bank Head (Figures 13, 14). Stop 2A is on the shore several hundred meters east of the parking spot; the remaining stops are located across the baymouth bar in the headlands to the west. Although the lower and upper parts of the section are readily accessible, Stops 2D and 2E require caution on the cliffs. Abundant ichnofossils are present in this section. Approximately 400 m of section will be examined. The northeasterly-dipping section is disrupted by numerous faults that have little offset.

STOP 2A Contact of the Rencontre Formation with underlying volcanics of the Marystown Group (PM)

Description.—The volcanics consist of red, purple and green welded ash-flow tuffs, and the Rencontre consists of red-bed conglomerate.

Dale (1927) considered this contact as a major structural disconformity with the volcanics striking northeast and dipping 30°S and the Rencontre rocks also striking northeast but dip-

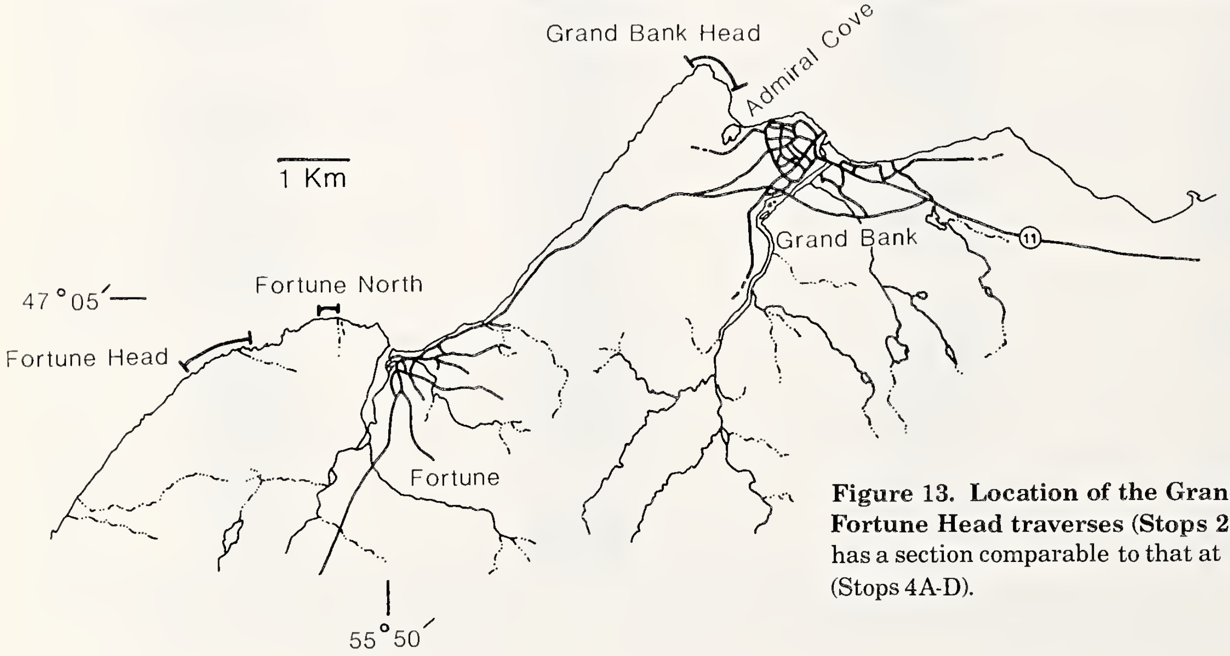


Figure 13. Location of the Grand Bank Head and Fortune Head traverses (Stops 2, 3). Fortune North has a section comparable to that at Little Dantzic Cove (Stops 4A-D).

ping 70°N. This contact was reinterpreted by O'Brien *et al.* (1977) as structurally conformable with the section west dipping and west facing.

Fossils.—None present.

At end of stop, continue west across baymouth bar to Grand Bank Head.

STOP 2B Middle and upper parts of the Rencontre Formation (PM)

Description.—Red, micaceous, fine grained, finely laminated sandstone, siltstones and mudstones. Sedimentary features (ripple marks, shrinkage cracks, intraformational conglomerate, and ball-and-pillow structures) are common. Thin to medium bedded sandstones contain parallel lamination and ripple crosslamination as well as scour-and-fill sandstones and clay-draped scour surfaces. Depositional environments for the lower part of the formation were probably fluvial but are more likely marginal marine or peritidal near the transition into the Chapel Island Formation.

Fossils.—Despite a thorough search, no fossils were noted.

STOP 2C Lowermost part of member 1 of the Chapel Island Formation (GBA-0 m to GBA-50 m) (PM, GMN)

Description.—Red and green sandstones, siltstones, and mudstones of Facies Association 1. Abundant dessication and synaeresis cracks, mud-chip conglomerate, current ripple marks, erosional surfaces and various other sedimentary structures imply deposition in tidally influenced, peritidal environments (Figure 15).

Fossils.—Trace fossils are not common and only a few specimens of *Intrites*?, *Planolites beverlyensis* and *P. montanus* have been noted. The assemblage suggests a late Precambrian age.

STOP 2D Member 1 of the Chapel Island Formation (GBA-95 m to GBA-120 m) (PM, GMN)

Description.—The steeply dipping strata are exposed at the head of a cove; the slope is steep and access may be difficult if the rocks are wet.

The rocks include grey-black laminated siltstones and shales with minor, thin to medium-bedded, grey-green sandstone beds (Facies Association 2) (Figure 15). Synaeresis cracks are locally abundant as are phosphate and pyrite nodules and synsedimentary folds and faults. The lenticular sandstone beds represent shallow channel-fills. The depositional environment is thought to be primarily subaqueous and represents partially be enclosed embayments or other semi-restricted, near shore settings (Myrow, 1987).

Fossils.—Trace fossils are typical of the late Precambrian *Harlaniella podolica* Zone and are dominated by simple, subhorizontal burrows (*Planolites*, *Gordia*, and *Harlaniella*). The vendotaenid alga *Tyrasotaenia* is common.

STOP 2E Lowermost part of member 2A of the Chapel Island Formation (GBA-187 m to GBA-215)

Description.—The strata (Figure 15) occur above a faulted and partly covered interval which includes the (unexposed)

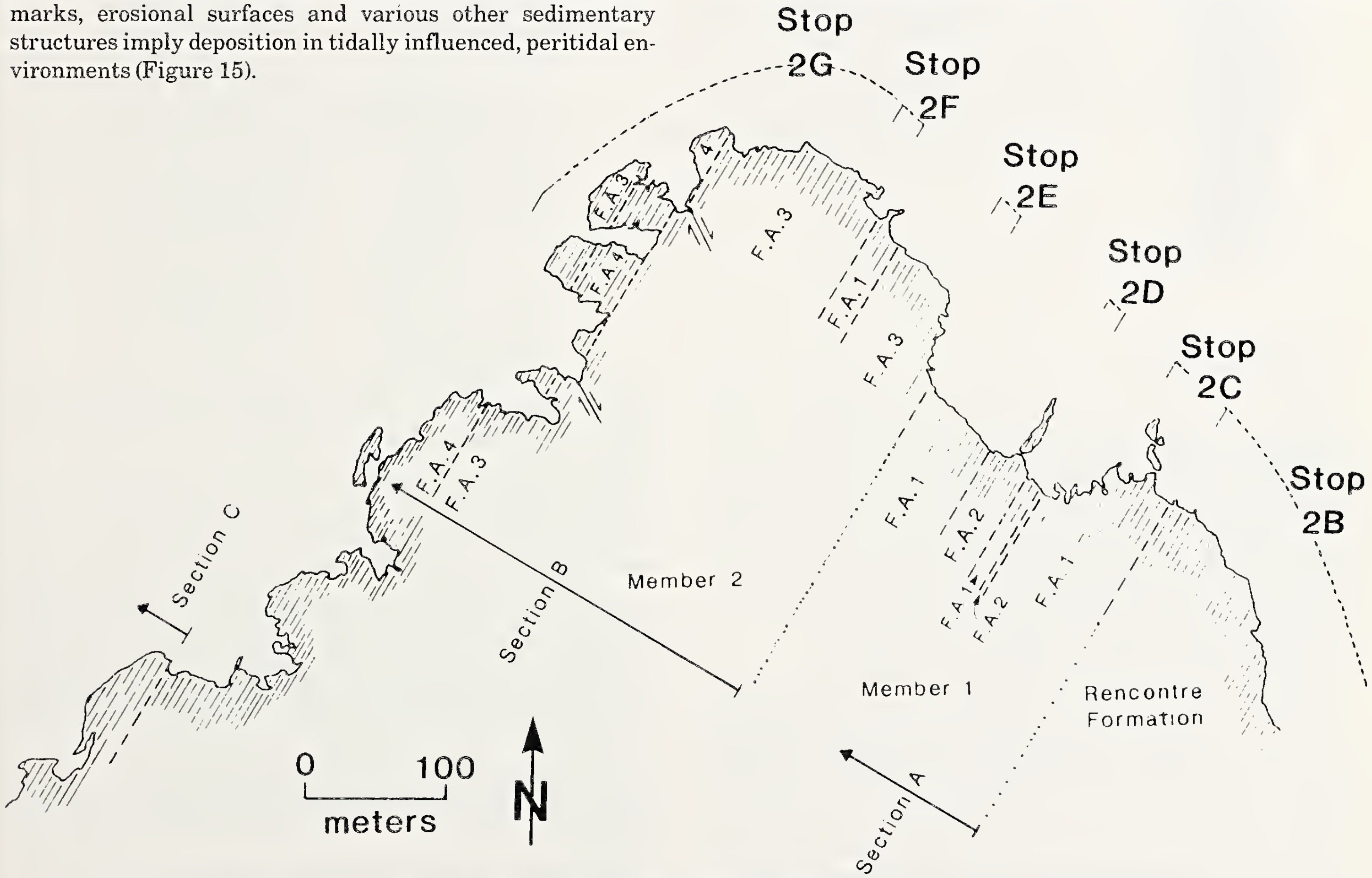


Figure 14. Detail map of Grand Bank Head (Stops 2B-2G). Diagonal ruling indicates strike.

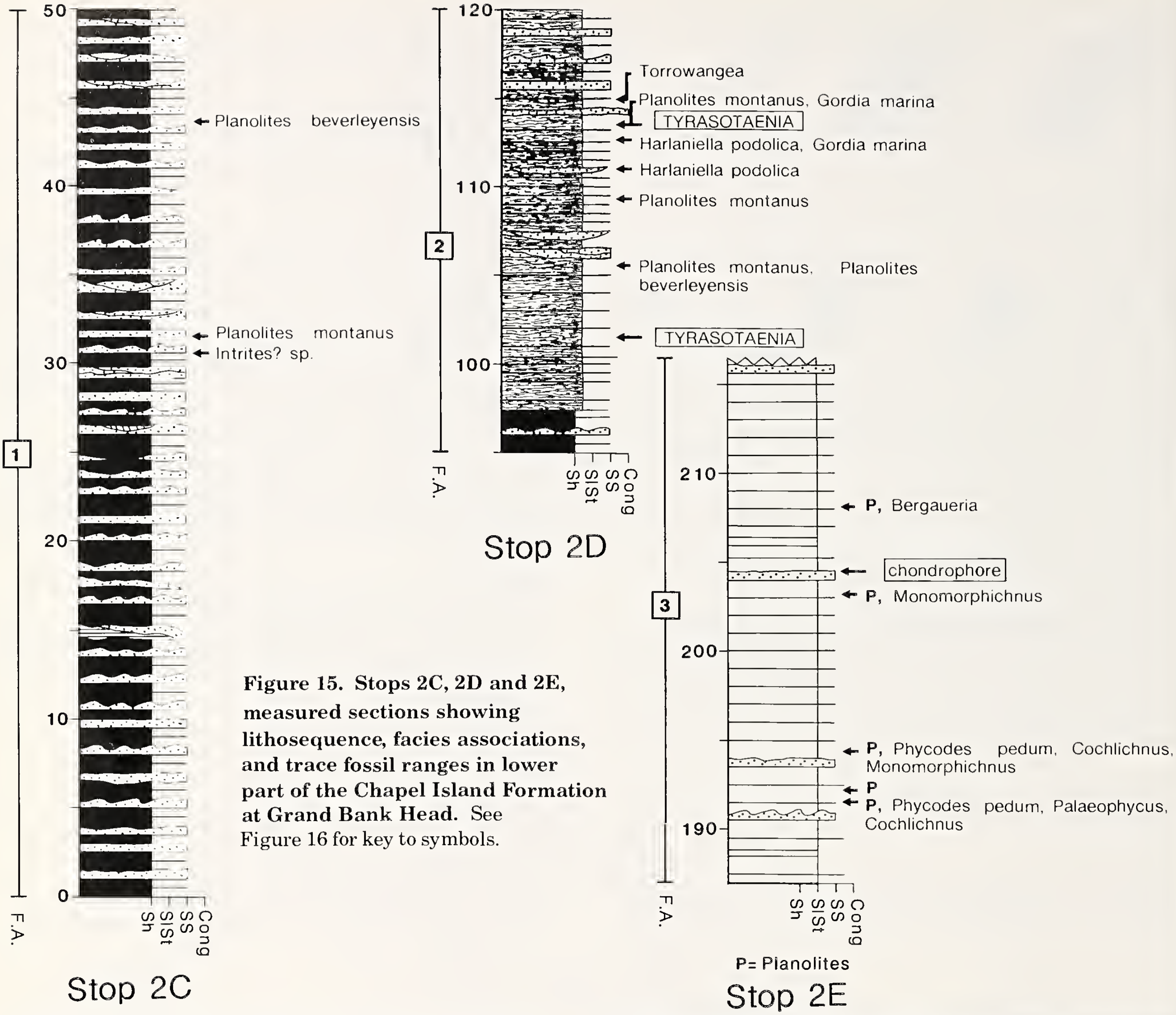


Figure 15. Stops 2C, 2D and 2E, measured sections showing lithosequence, facies associations, and trace fossil ranges in lower part of the Chapel Island Formation at Grand Bank Head. See Figure 16 for key to symbols.

member 1 – member 2A boundary. The rocks include silver-green siltstone with very thin to thin beds of grey-green sandstone (Facies Association 3). The sandstones are commonly discontinuous and have abundant sandstone dikes and pot and gutter casts (e.g. casts of erosional depressions and channels). These features are diagnostic of a "gutter cast facies" also found at the base of member 2A at the Fortune Head locality (Stops 2B, 3C). These features are considered to indicate storm-influenced, shallow, subtidal environments.

Fossils.—*Phycodes pedum* is found at several levels and indicates the basal Cambrian *Phycodes pedum* Zone. Other zonal associates include the arthropod trace *Monomorphichnus* and the probable coelenterate burrow *Bergaueria*. The impression of a soft-bodied megafossil, a chondrophore similar to *Spriggia*, was found 13 m above the lowest specimens of *Phycodes pedum* on the sole of a sandstone bed. Similar fossils also occur in the Rovno beds of the East European Platform (Sokolov and Fedonkin, 1984).

STOP 2F Member 2A of the Chapel Island Formation GBB-0 m to GBB-35 m) (PM, GMN))

Description.—The silver-green siltstones with very thin to thin beds of grey-green sandstone (Facies Association 3) are intensely burrowed (Figure 17). The depositional environment is interpreted as a storm-influenced, subtidal, deltaic system.

Fossils.—Trace fossils are well exposed on most bedding soles. *Phycodes pedum*, *Arenicolites*, *Skolithos* and *Treptichnus* are all Cambrian-type traces. Specimens of *Dimorphichnus* and very shallow (less than 2 mm-deep) *Rusophycus avalonensis* allow a referral to the *Rusophycus avalonensis* Zone.

STOP 2G Member 2A and lower member of 2B of the Chapel Island Formation (GBB-35 m to GBB-190 m) (PM, GMN)

Description.—Silver-green siltstone and very thin to thin beds of grey-green sandstone (Facies Association 3) form the lower and upper parts of the section (Figure 18). Red and green laminated siltstones (Facies Association 4) are found in the middle (GBB-120 m to ca. GBB-150 m). The 5.2 m-thick red siltstone at GBB-120 defines the base of member 2B; this marker horizon occurs throughout the southwestern Burin Peninsula. Facies Association 4 is a fine-grained silty blanket marking intervals of delta abandonment.

Fossils.—Trace fossils are abundant and include the Cambrian-type forms *Phycodes pedum*, *P. coronatum*, *Treptichnus*, *Diplocraterion*, *Helminthopsis abeli*, *Diplichnites*, *Helminthoida*, *Cosmorhaphe* and *Rusophycus*. The interval represents the *Rusophycus avalonensis* Zone.

At the end of the stop, walk to the vehicles and return to Marystown.

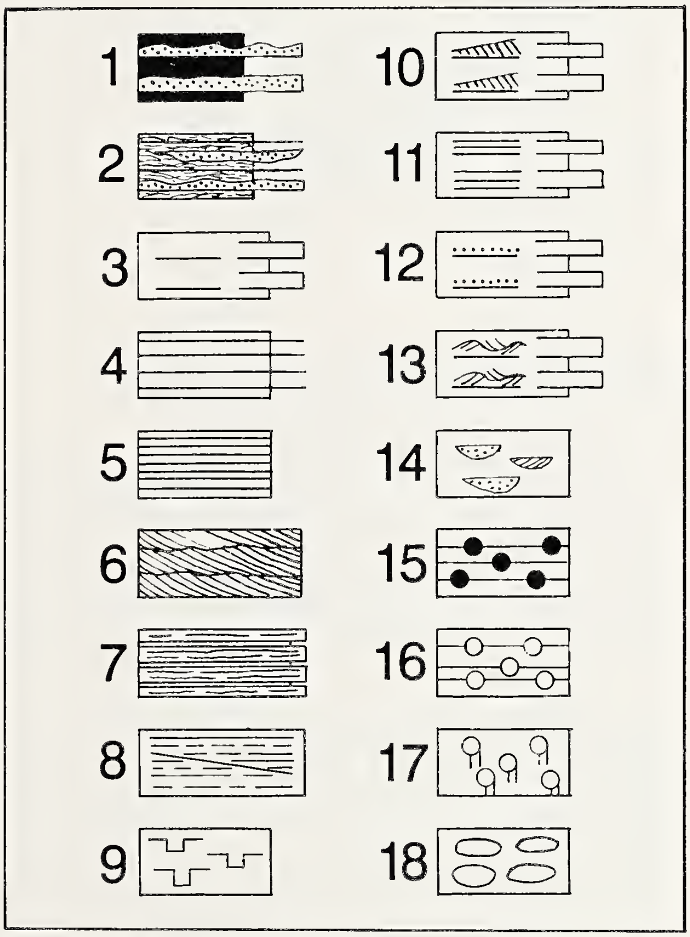


Figure 16. Legend for stratigraphic sections of the Chapel Island Formation: 1, Thin to medium bedded red and green sandstones and shales; 2, Gray to black laminated silty shale; 3, Thin to medium bedded green sandstones and siltstones; 4, Very thin bedded sandstones and siltstones; 5, Sandstone and laminated siltstone; 6, Trough cross-stratified sandstones; 7, Medium to thick bedded micaceous red sandstones; 8, Thick to very thick bedded micaceous red sandstrones; 9, Gutter casts and pot casts; 10, Ripple cross-lamination; 11, Parallel lamination; 12, Graded bedding; 13, Hummocky cross-stratification; 14, Sandstone scour-andfills; 15, Phosphate nodules; 16, Pyrite nodules; 17, Bioturbation; 18, Carbonate nodules.

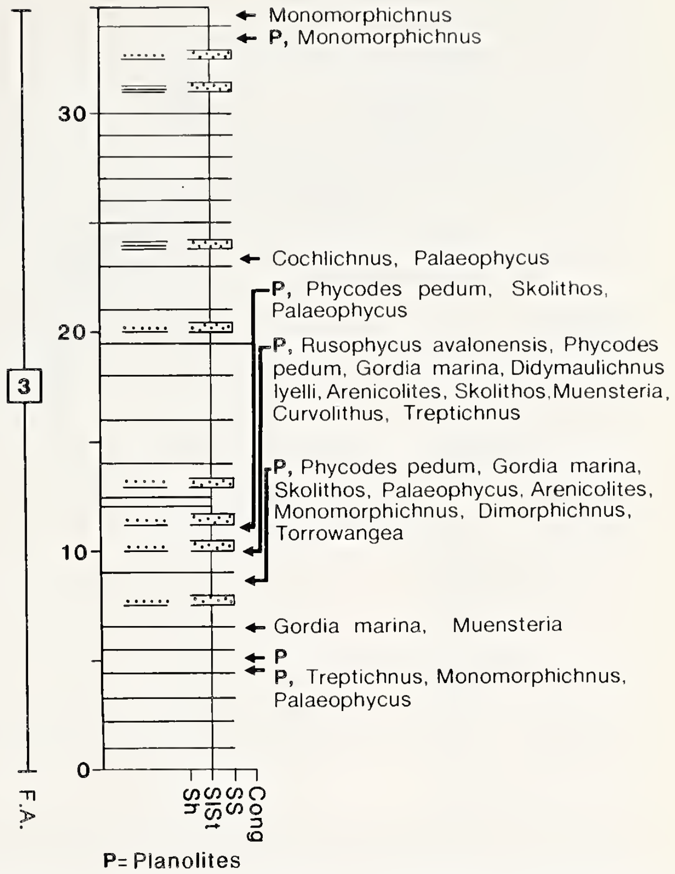

Monomorphichnus
P, Monomorphichnus
30
Cochlichnus, Palaeophycus
P, Phycodes pedum, Skolithos, Palaeophycus
20
3
P, Rusophycus avalonensis, Phycodes pedum, Gordia marina, Didymaulichnus lyelli, Arenicolites, Skolithos, Muensteria, Curvolithus, Treptichnus
P, Phycodes pedum, Gordia marina, Skolithos, Palaeophycus, Arenicolites, Monomorphichnus, Dimorphichnus, Torrowangea
10
Gordia marina, Muensteria
P
P, Treptichnus, Monomorphichnus, Palaeophycus
0
F.A.
Sh
SiSt
SS
Cong
P= Planolites

Figure 17. Measured section at Stop 2F in member 2A of the Chapel Island Formation at Grand Bank Head. See Figure 16 for explanation.

DAY 3

0.0	Depart from hotel and take Rte. 210 west and then Rte. 220 south to the City of Fortune.
61	City of Fortune. Proceed 2.7 km south of center of city on Rte. 220.
63.7	Turn west (right) on gravel road and drive across creek valley and ridge to lighthouse, park vehicles.
67	Fortune Head. The base of the Fortune Head section lies several hundred meters east of the lighthouse and continues westward along the coast for approximately 1 km (Figure 19). The section is a continuous series of low sea cliffs in the Chapel Island Formation that are readily accessible by foot. The strata dip northwest at 15-46° with dip increasing up-section. A few faults are present but marker horizons allow easy correlation across them. The completely exposed section is divided into "stops" solely to focus discussion.

STOP 3A Uppermost Precambrian (upper member 1 of the Chapel Island Formation) (GMN, PM)

Description.—The strata are predominantly red and green sandstones and shales (Facies Association 1) and gray-black laminated siltstones and shales with minor, thin-medium bedded, grey-green sandstones (Facies Association 2). The rocks of Facies Association 1 contain abundant desiccation cracks

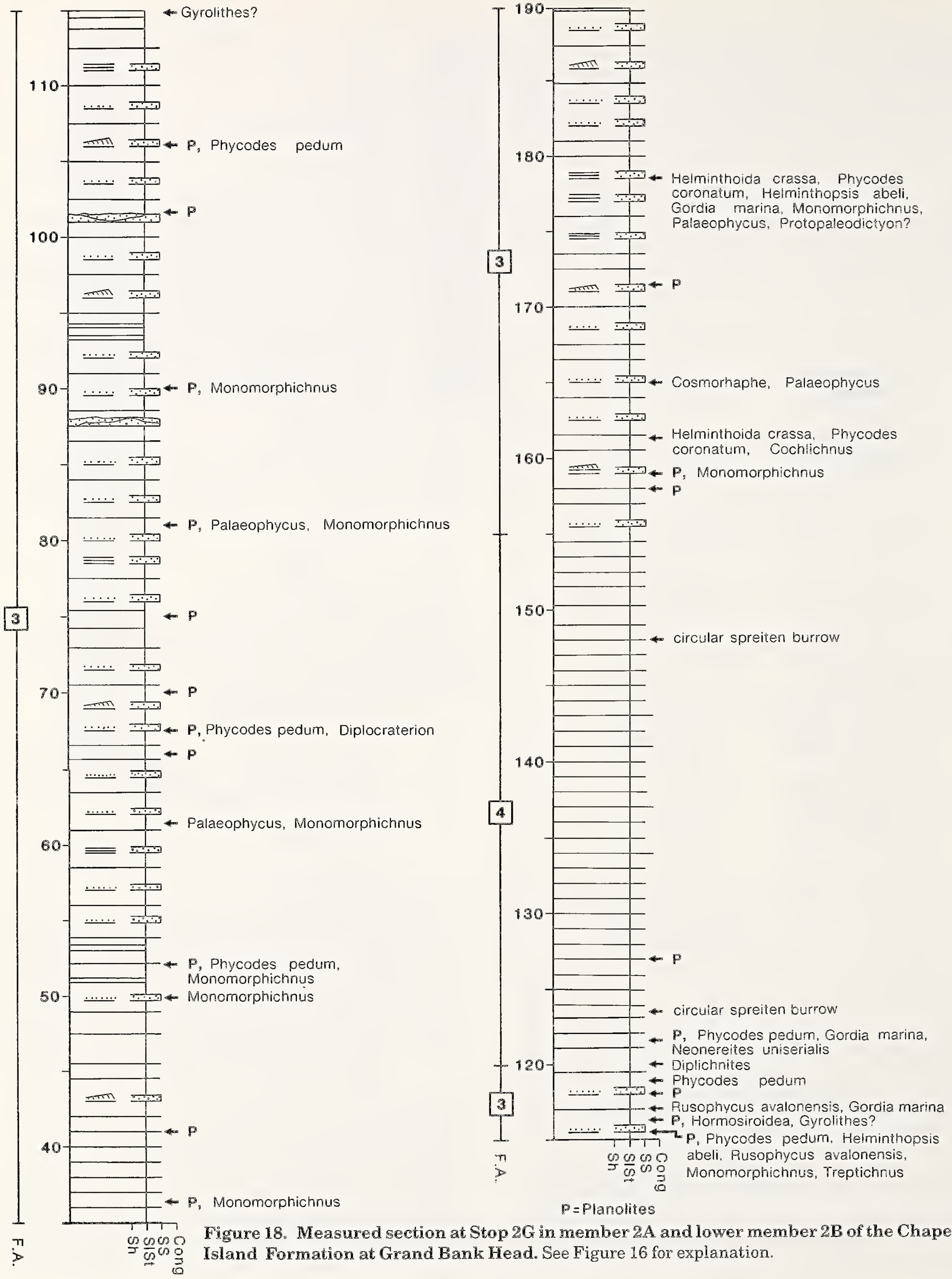

Gyrolithes?
110
P, Phycodes pedum
P
100
90
P, Monomorphichnus
P, Palaeophycus, Monomorphichnus
80
3
P
70
P
P, Phycodes pedum, Diplocraterion
P
Palaeophycus, Monomorphichnus
60
P, Phycodes pedum, Monomorphichnus
50
Monomorphichnus
P
40
P, Monomorphichnus
F.A.
Sh
SlSt
SS
Cong
190
180
Helminthoida crassa, Phycodes coronatum, Helminthopsis abeli, Gordia marina, Monomorphichnus, Palaeophycus, Protopaleodictyon?
3
P
170
Cosmorhaphe, Palaeophycus
Helminthoida crassa, Phycodes coronatum, Cochlichnus
160
P, Monomorphichnus
P
150
circular spreiten burrow
140
4
130
P
circular spreiten burrow
P, Phycodes pedum, Gordia marina, Neonereites uniserialis
120
Diplichnites
Phycodes pedum
P
3
Rusophycus avalonensis, Gordia marina
P, Hormosiroidea, Gyrolithes?
P, Phycodes pedum, Helminthopsis abeli, Rusophycus avalonensis, Monomorphichnus, Treptichnus
F.A.
Sh
SlSt
SS
Cong
P = Planolites

Figure 18. Measured section at Stop 2G in member 2A and lower member 2B of the Chapel Island Formation at Grand Bank Head. See Figure 16 for explanation.

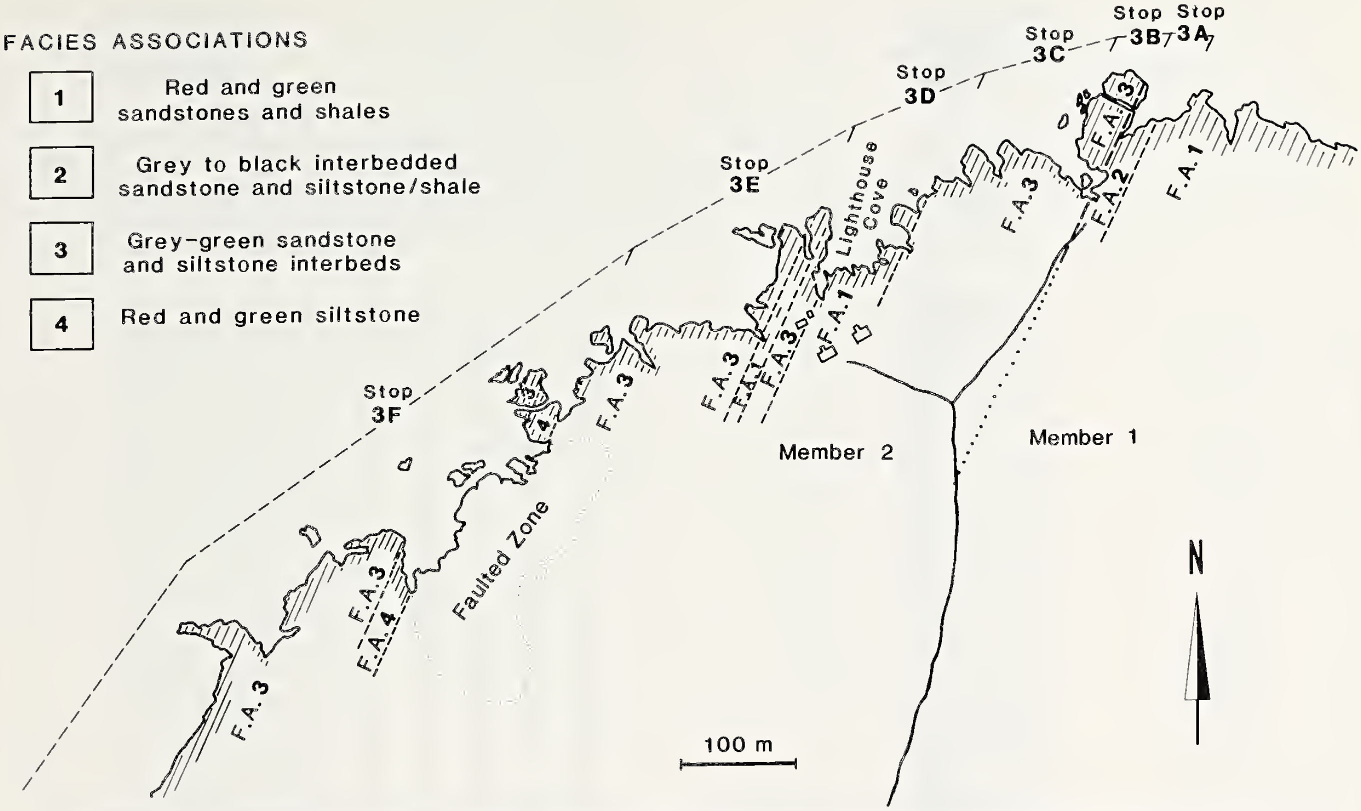

FACIES ASSOCIATIONS
1 Red and green sandstones and shales
2 Grey to black interbedded sandstone and siltstone/shale
3 Grey-green sandstone and siltstone interbeds
4 Red and green siltstone
Stop 3A
Stop 3B
Stop 3C
Stop 3D
Stop 3E
Stop 3F
Lighthouse Cove
F.A.1
F.A.2
F.A.3
F.A.4
Faulted Zone
Member 2
Member 1
N
100 m

Figure 19. Detail map of the Fortune Head section (Stops 3A-F), southern Burin Peninsula, southeastern Newfoundland. Diagonal ruling indicates strike.

and other sedimentary structures indicating deposition in tidally-influenced, peritidal conditions. Facies Association 2 has locally abundant synaeresis cracks and a few desiccation cracks. The depositional environment is considered to be in a semirestricted, nearshore, shallow subtidal setting that was subjected to rare periods of subaerial exposure. The strata correspond roughly to the interval (GBA-80-100) at the Grand Bank Head (Stop 2D) exposure.

Fossils.—Fossils are rare and occur mostly in the grayblack units. Trace fossils include simple forms such as *Planolites montanus*, *P. beverlyensis* and *Gordia marina*. Wellpreserved examples of *Sabellidites cambriensis* and the vendotaenid alga *Tyrasotaenia* occur in the darker, shalier units. One impression of a soft-bodied ('medusoid') organism was found near the top of these strata. The overall composition of the fauna and flora suggest a latest Precambrian age.

STOP 3B Candidate Precambrian-Cambrian Boundary Stratotype Point and Horizon (GMN, PM, EL)

Description.—The stop includes uppermost member 1 and lower member 2A of the Chapel Island Formation (FH-15 m to FH-30 m) above a minor fault (Figure 20). The boundary between members 1 and 2 of the Chapel Island Formation occurs 18.2 m above the base of the section. The candidate Precambrian-Cambrian Boundary Stratotype Horizon and Point is located 2.4 m above the base of member 2.

The uppermost strata of member 1 of the Chapel Island Formation consist of grey-black siltstones and shales with gray-green sandstones displaying desiccation and synaeresis cracks (Facies Association 2). These were deposited under peritidal and semirestricted nearshore conditions. The upper contact of member 1 is a prominent bench that exhibits broad shallow scours, shrinkage cracks and clasts of phosphatic shale. These features, which are common in Facies Association 2, imply possible subaerial exposure (a normal event in peritidal environments). There is no evidence, however, for extended erosion in this or any other bed in these lower members.

The basal beds of member 2 in this promontory consist of silver-green siltstone and grey-green fine sandstones (Facies Association 3). Sandstones are very thin to thin bedded and are laterally discontinuous; gutter casts and pot casts are very abundant. The sedimentary structures indicate that these sandstones are tempestites. Coupled with evidence for high sedimentation rate (numerous sandstone dikes and siltflow/liquefied-flow deposits), the inferred depositional environment is a river-dominated, storm-influenced muddy delta front.

Fossils.—Fossils are abundant and are used to define the Precambrian-Cambrian boundary. Member 1 and the basal 2.4 m of member 2 represent the uppermost *Harlaniella podolica* Zone. This zone is characterized by a low diversity trace fossil assemblage dominated by simple subhorizontal burrows (*Planolites*, *Gordia*, *Harlaniella* and *Palaeopascichnus*). The latter two ichnogenera are particularly valuable age indicators as they apparently are restricted to the upper Precambrian (see: "Trace Fossil Biostratigraphy"). The vendotaenid alga *Tyrasotaenia* is also common.

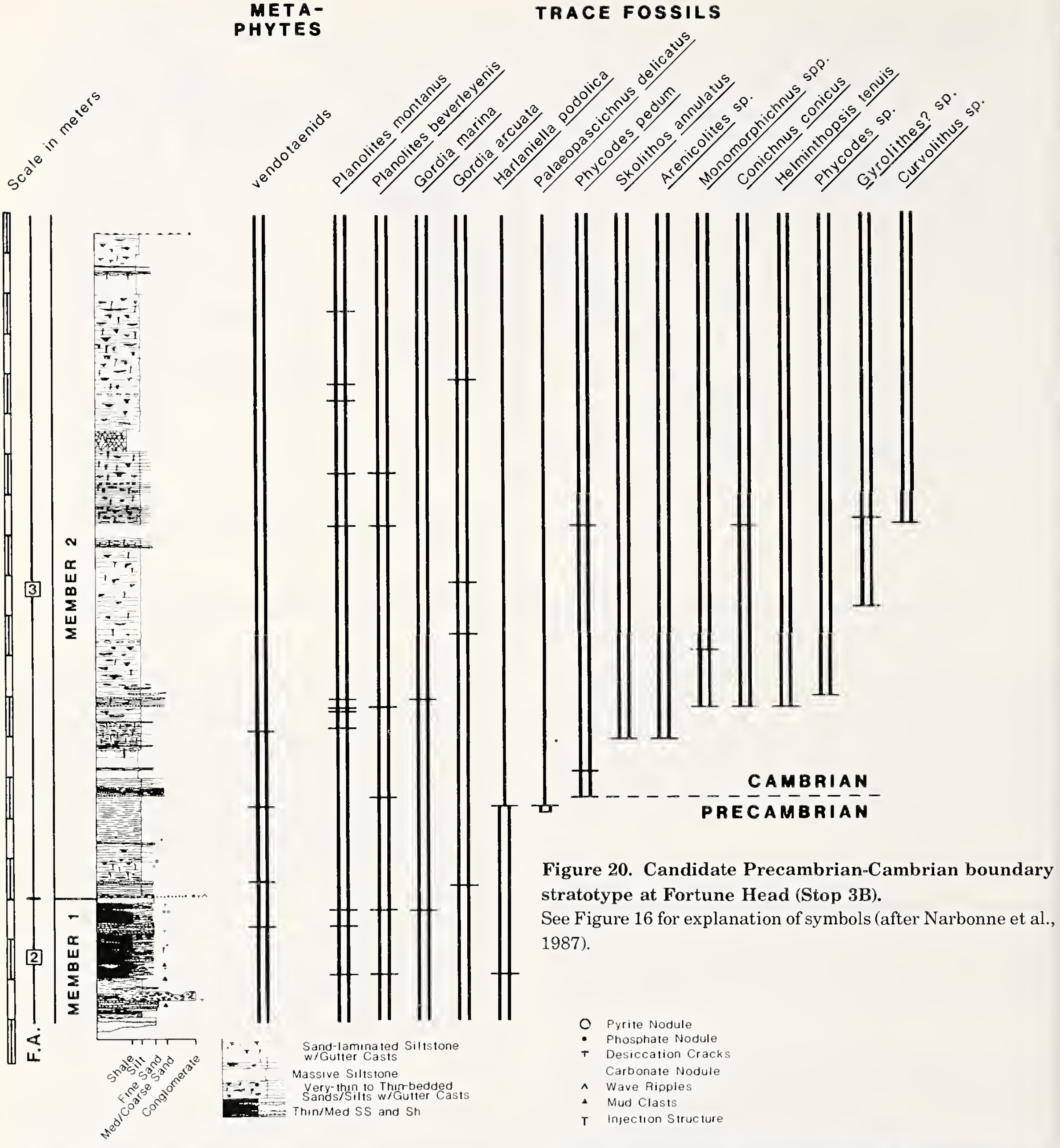
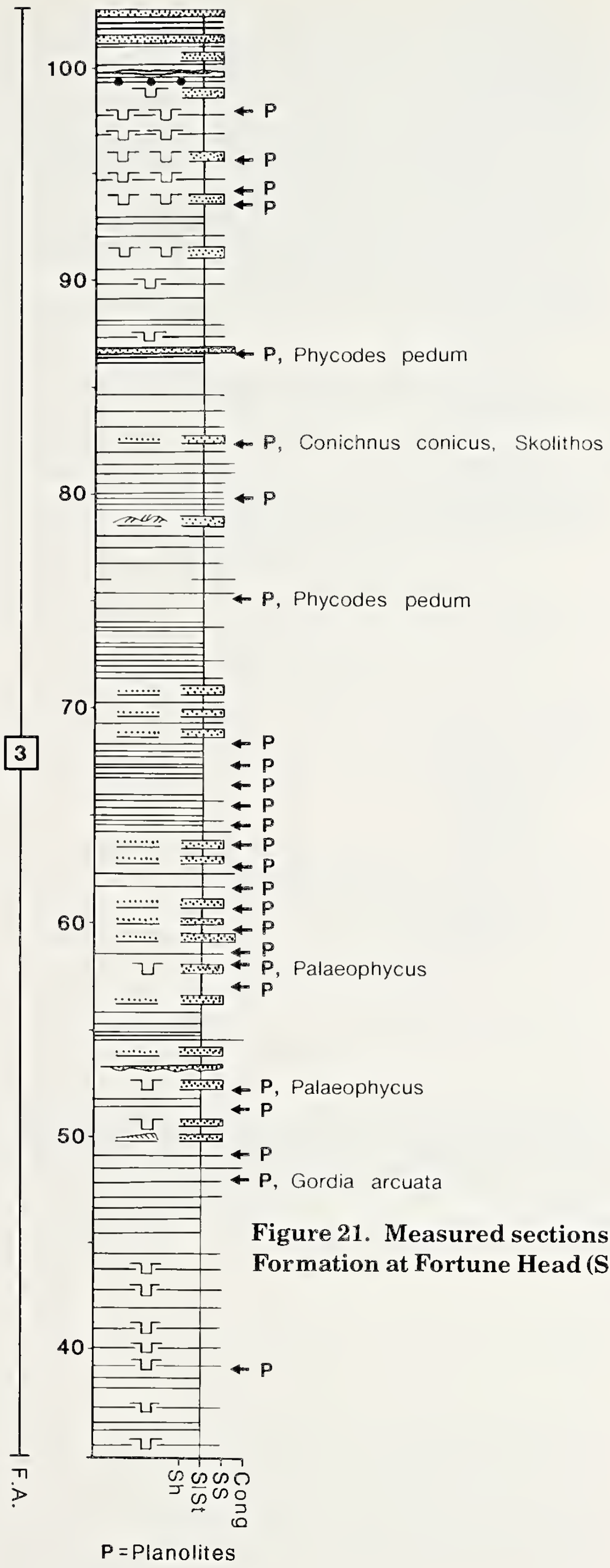


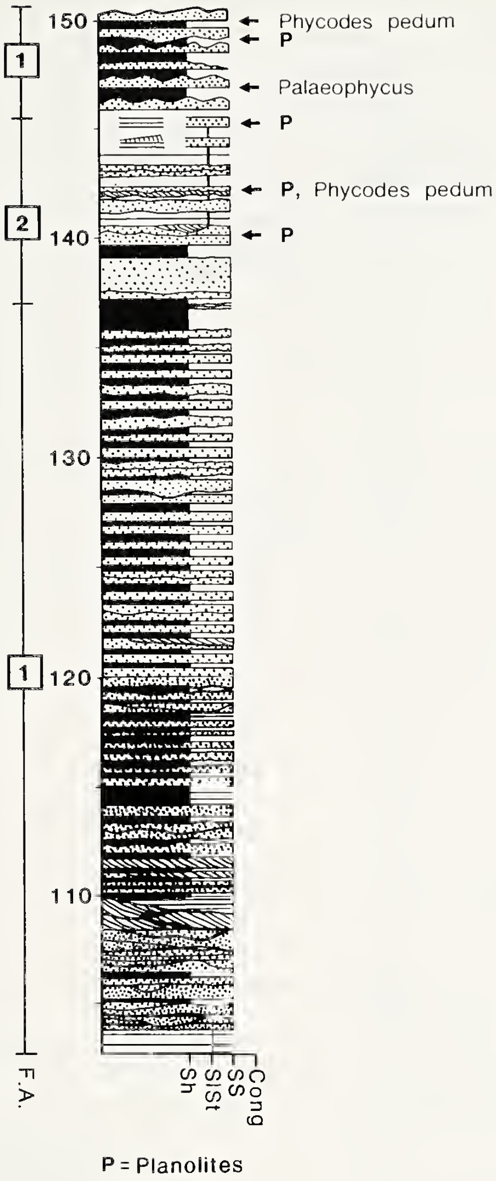
Figure 20. Candidate Precambrian-Cambrian boundary stratotype at Fortune Head (Stop 3B).
See Figure 16 for explanation of symbols (after Narbonne et al., 1987).

Phycodes pedum first appears 2.4 m above the base of member 2 and is used to define the base of the *Phycodes pedum* Zone. This lowest occurrence has been proposed as a candidate stratotype point and horizon for the Precambrian-Cambrian boundary (Narbonne *et al.* 1987). Participants should check this level carefully to test our claims that the proposed boundary horizon occurs within a continuous and relatively uniform succession of subtidal strata. It is also significant that the highest occurrence of Vendian ichnofossils (*Harlaniella podolica* and *Palaeopascichnus delicatus*) is only 0.2 m lower in the section and in the same lithofacies.

Higher strata of member 2 at this stop contain the elements of the *Phycodes pedum* Zone, including arthropod traces (*Monomorphichnus*), vertical dwelling burrows (*Skolithos* and *Arenicolites*) and coelenterate resting burrows (*Conichnus*). Vendotaenid algae occur sporadically in these strata. The fau-



Stop 3C



Stop 3D

Figure 21. Measured sections in lower and middle parts of member 2A of the Chapel Island Formation at Fortune Head (Stops 3C, D). See Figure 16 for explanation.

nal assemblage is closely similar to the *Phycodes pedum* Zone at Grand Bank Head (Stop 2D). Small shelly fossils were not recovered from the scattered calcareous nodules and calcite-cemented sandstones of the interval.

STOP 3C Coastline from Stop 2B to east edge of "Lighthouse Cove" (Figure 21) (GMN, PM, EL)

Description.—The section includes the lower part of member 2A of the Chapel Island Formation (FH-35 m to FH-103 m). The alternating grey-green sandstones and siltstones (Facies Association 3) are similar to those of Stop 2B. The deposition occurred in storm-influenced, shallow subtidal environments.

Fossils.—Trace fossils are abundant on nearly every sole. *Phycodes pedum* and other ichnofossils typical of the *Phycodes pedum* Zone are rare and most traces are simple, biostratigraphically non-diagnostic forms. Small shelly fossils were not recovered from the relatively abundant calcareous nodules in this interval.

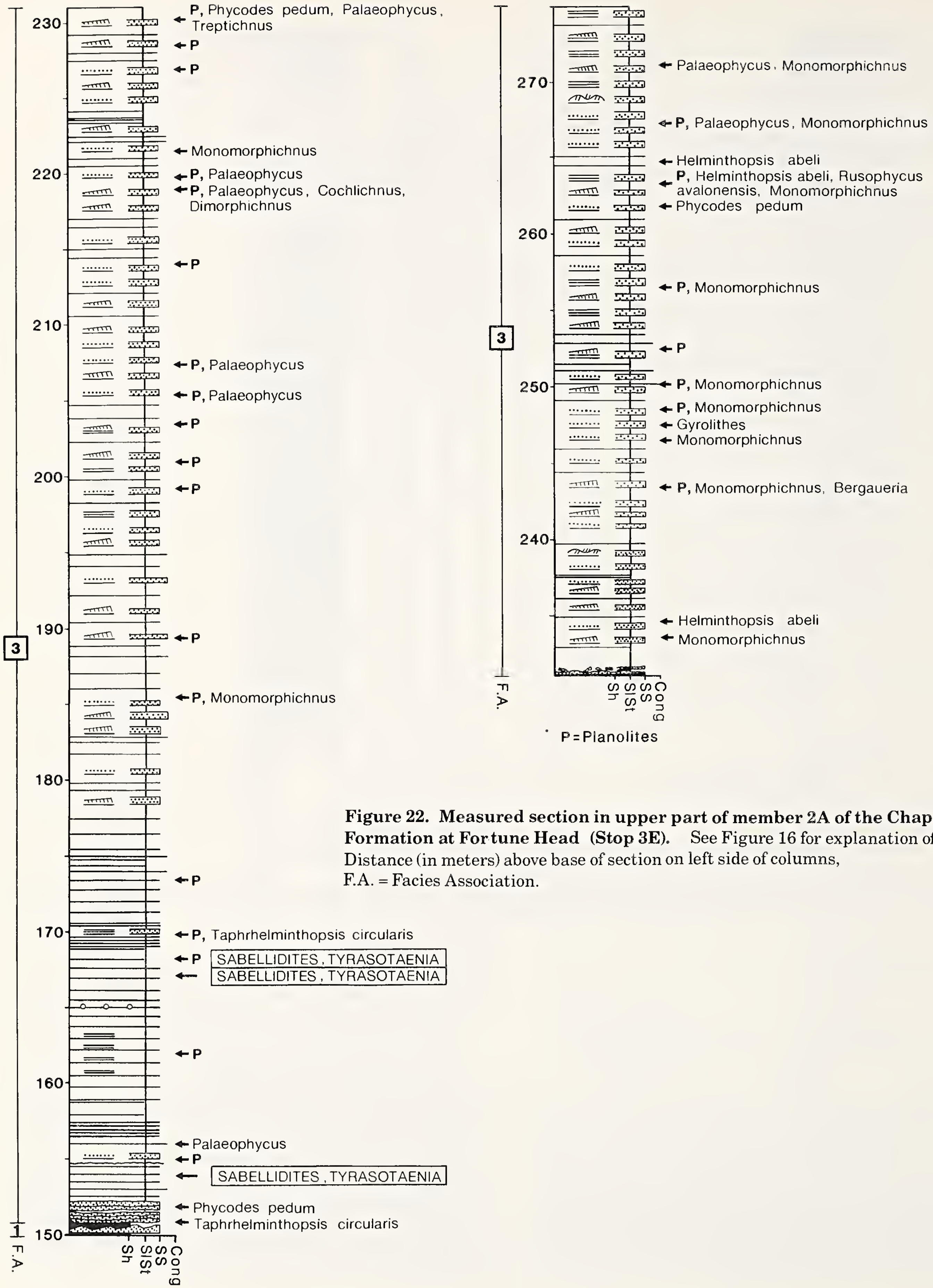

230
220
210
200
190
180
170
160
150
3
1
F.A.
Sh
SlSt
SS
Cong
P, Phycodes pedum, Palaeophycus, Treptichnus
P
P
Monomorphichnus
P, Palaeophycus
P, Palaeophycus, Cochlichnus, Dimorphichnus
P
P, Palaeophycus
P, Palaeophycus
P
P
P
P
P, Monomorphichnus
P
P, Taphrhelminthopsis circularis
P
SABELLIDITES, TYRASOTAENIA
SABELLIDITES, TYRASOTAENIA
P
Palaeophycus
P
SABELLIDITES, TYRASOTAENIA
Phycodes pedum
Taphrhelminthopsis circularis
270
260
250
240
3
F.A.
Palaeophycus, Monomorphichnus
P, Palaeophycus, Monomorphichnus
Helminthopsis abeli
P, Helminthopsis abeli, Rusophycus avalonensis, Monomorphichnus
Phycodes pedum
P, Monomorphichnus
P
P, Monomorphichnus
P, Monomorphichnus
Gyrolithes
Monomorphichnus
P, Monomorphichnus, Bergaueria
Helminthopsis abeli
Monomorphichnus
Sh
SlSt
SS
Cong
P=Planolites

Figure 22. Measured section in upper part of member 2A of the Chapel Island Formation at Fortune Head (Stop 3E). See Figure 16 for explanation of symbols. Distance (in meters) above base of section on left side of columns, F.A. = Facies Association.

STOP 3D "Lighthouse Cove" (PM, GMN, EL)

Description.—The middle part of member 2A (FH-103 m to FH150 m) are exposed in low (5-10 m), steep sea cliffs. Approximately 33 m of relatively inaccessible, red sandstone and shale (Facies Association 1) occur in the eastern and southern wall of the cove. Abundant desiccation and synaeresis cracks suggest a return to peritidal conditions. The west wall of the cove exposes a shoaling-channel sequence that begins with subtidal grey sandstones and siltstones (Facies Association 3: shallow subtidal) and is capped with red and green sandstones and shales with abundant dessication features (Facies Association 1: peritidal).

Fossils.—The thick, lower package of peritidal red sandstones and shales on the south side of the cove is apparently unfossiliferous. The overlying subtidal and peritidal portions of the shoaling-channel sequence contain *Phycodes pedum* Zone traces. This part of the section is nearly devoid of calcareous nodules or sands appropriate for acid-disaggregation of small shelly fossils (Figure 21).

STOP 3E Section west of "Lighthouse Cove" (GMN, PM, EL)

Description.—The strata of upper member 2A of the Chapel Island Formation are exposed in low sea cliffs (Figure 22). The grey green sandstones and siltstones (Facies Association 3) were deposited in storm-influenced, subtidal, deltaic environments.

Fossils.—*Taphrhlmenthopsis circularis*, a guide fossil for the *Rusophycus avalonensis* Zone, first occurs 152 m above the base of member 2. This is approximately at the same level that *Rusophycus avalonensis* Zone ichnofossils (e.g. *Rusophycus* and *Dimorphichnus*) first occur at Grand Bank Head (Stop 2E). The lower diversity at Fortune Head, in comparison to Grand Bank Head, reflects the relative scarcity of lower bedding surfaces in this part of the section. Other ichnofossils of the *Rusophycus avalonensis* Zone, including *Helminthopsis abeli* and *R. avalonensis*, occur where soles are exposed higher in the section (Figure 22). The highest observed specimens of *Sabellidites cambriensis* and the vendotaenid *Tyrasotaenia* occur low in the *Rusophycus avalonensis* zone at this locality. Calcareous nodules again become abundant in the upper part of this section; however, no small shelly fossils were recovered from them.

STOP 3F Western end of the Fortune Head section (GMN, PM, EL)

Description.—A complete section of member 2B of the Chapel Island Formation is exposed at this stop (FH-275 m to FH-435 m) (Figure 23). A fault cuts diagonally across the section; strata up to ca. 340 m are exposed on the west side of the fault while the ca. 308 m to 435 + m interval is exposed on the east side. Marker beds can be used to correlate between the two fault blocks.

Facies Association 4 defines the base of member 2B and is present on both sides of the fault. It consists of red and green siltstone with local sandy laminae, carbonate concretions, and pyrite and phosphate nodules. Packages of this facies association are excellent marker units that are traceable for tens of kilometers along the coast. Facies Association 4 represents an extensive fine-grained blanket marking periods of low sediment supply during delta abandonment.

Strata higher in member 2B consist of gray-green sandstones and siltstones that are lithologically indistinguishable from those that make up most of member 2A (= Facies Association 3: storm-influenced subtidal shelf). Near the top of the section, sandstone bed thickness and total sandstone content decrease as the strata pass into the laminated silver-green siltstones of member 3. The transition is gradational and is arbitrarily drawn at the top of the highest sandstone bed that is more than 5 cm thick in the Fortune Head section. At the end of the section, the outcrop roughly parallels the strike of bedding and the rocks are highly faulted.

Fossils.—Trace fossils are common in the gray-green sandstones and siltstones and less common in the red and green siltstones. The assemblage is typical of the *Rusophycus avalonensis* Zone. An unnamed circular spreiten-burrow 1-3 dm in diameter occurs at several levels low in member 2B. Other trace fossils include *Helmenthopsis abeli* and *Gyrolithes sp.*

A large bedding surface covered with the complexly meandering burrow *Helminthoida crassa* occurs at the western end of the outcrop belt. Mesozoic and Tertiary examples of this ichnospecies are found exclusively in deep water slope and basinal settings, whereas the Chapel Island specimens occur on a subtidal shelf. This supports other evidence that trace fossils were less influenced by environmental factors in the Early Cambrian than later in the Phanerozoic (Crimes and Anderson 1985). Bathymetric models for trace fossil distribution (e.g., Seilacher 1967) are therefore less appropriate and trace fossils have greater utility as index fossils in the Early Cambrian than in any other interval of the Phanerozoic.

Despite a thorough sampling of calcareous nodules and sandstones and examination of outcrop surfaces, calcareous- or phosphatic-walled skeletal fossils were not recovered until near the top of the Fortune Head section. Several poorly preserved internal molds of a conch referred to "*Ladatheca*" *cylindrica* (Grabau) higher in the Chapel Island Formation were collected from green mudstones approximately 393 m above the base of the section. Well-preserved specimens of "*L.*" *cylindrica* appear to be identical to many "species" of simple tubes brought to such genera as *Circotheca, Turcutheca, Loculitheca, Uniformitheca*, etc. in Asian sections (Landing, In press). Small shelly fossils allow the recognition of a "*Sabellidites cambriensis* Interval" (= *Harlaniella podoloca* through lowest *Rusophycus avalonensis* Zones). The " '*Ladatheca*' *cylindrica* Interval" extends from upper member 2B into member 3 (Stop 4) of the Chapel Island Formation.

At the end of the stop, walk to the vehicles and return to Marystown.

DAY 4

0.0	Depart from hotel and take Rte. 210 west and then Rte. 220 (= old Rte. 11) south through the City of Fortune.
84	Turn right onto two-lane gravel road to Pieduck Point and park near wharf (Figure 24)
86.3	Pieduck Point (EL)

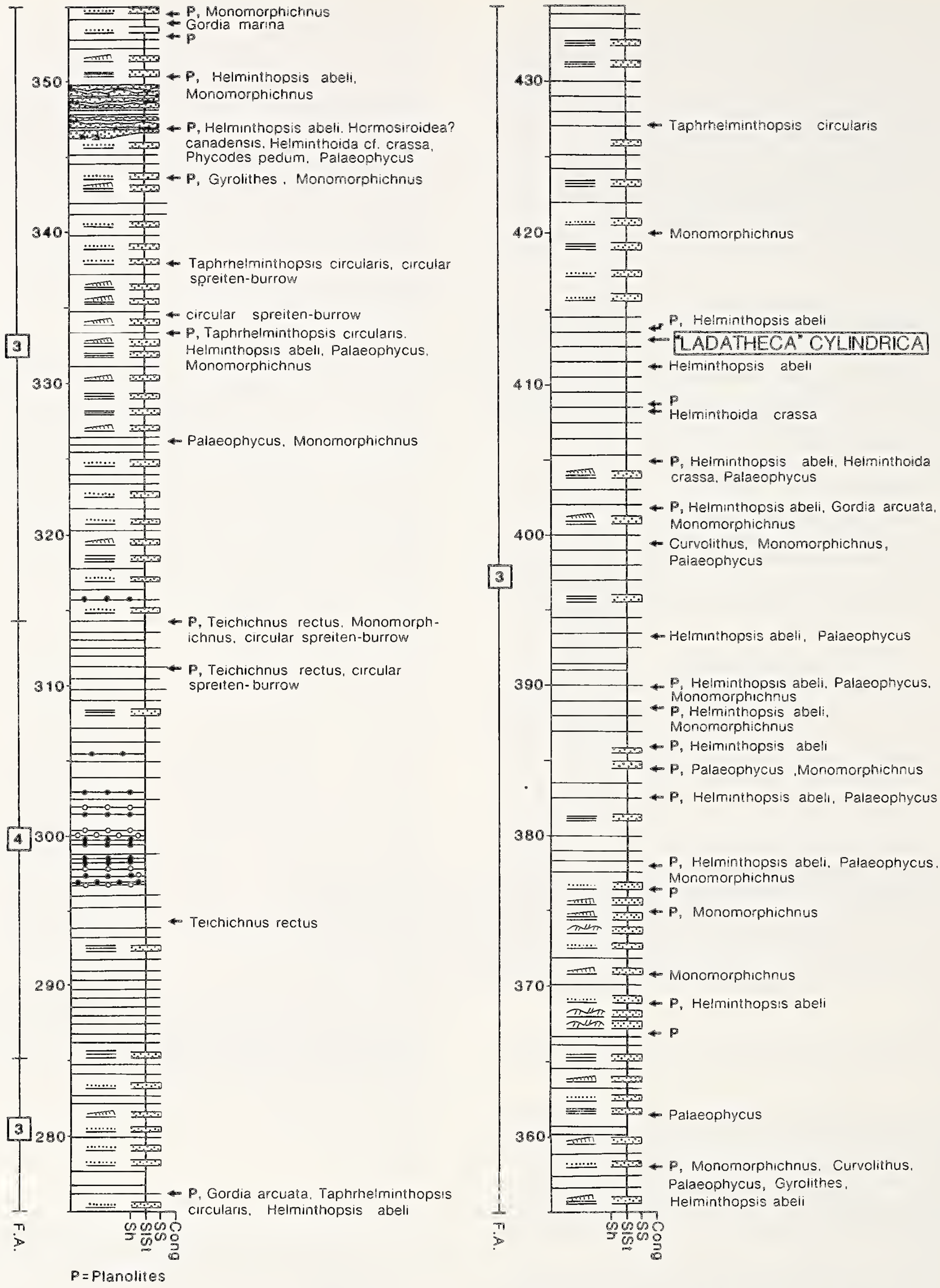

P, Monomorphichnus
Gordia marina
P
P, Helminthopsis abeli, Monomorphichnus
P, Helminthopsis abeli, Hormosiroidea? canadensis, Helminthoida cf. crassa, Phycodes pedum, Palaeophycus
P, Gyrolithes , Monomorphichnus
Taphrhelminthopsis circularis, circular spreiten-burrow
circular spreiten-burrow
P, Taphrhelminthopsis circularis, Helminthopsis abeli, Palaeophycus, Monomorphichnus
Palaeophycus, Monomorphichnus
P, Teichichnus rectus, Monomorphichnus, circular spreiten-burrow
P, Teichichnus rectus, circular spreiten-burrow
Teichichnus rectus
P, Gordia arcuata, Taphrhelminthopsis circularis, Helminthopsis abeli
350
340
330
320
310
300
290
280
3
4
3
F.A.
Sh
SISt
SS
Cong
P=Planolites
430
420
410
400
390
380
370
360
3
F.A.
Taphrhelminthopsis circularis
Monomorphichnus
P, Helminthopsis abeli
'LADATHECA' CYLINDRICA
Helminthopsis abeli
P
Helminthoida crassa
P, Helminthopsis abeli, Helminthoida crassa, Palaeophycus
P, Helminthopsis abeli, Gordia arcuata, Monomorphichnus
Curvolithus, Monomorphichnus, Palaeophycus
Helminthopsis abeli, Palaeophycus
P, Helminthopsis abeli, Palaeophycus, Monomorphichnus
P, Helminthopsis abeli, Monomorphichnus
P, Helminthopsis abeli
P, Palaeophycus ,Monomorphichnus
P, Helminthopsis abeli, Palaeophycus
P, Helminthopsis abeli, Palaeophycus, Monomorphichnus
P
P, Monomorphichnus
Monomorphichnus
P, Helminthopsis abeli
P
Palaeophycus
P, Monomorphichnus, Curvolithus, Palaeophycus, Gyrolithes, Helminthopsis abeli
Sh
SISt
SS
Cong

Figure 23. Measured section through member 2B of the Chapel Island Formation at Fortune Head (Stop 3F). See Figure 16 for explanation of symbols. Distance (in meters) above base of section on left side of columns, F.A. = Facies Association.

A complete section from lower member 3 of the Chapel Island Formation through the upper part of the Chamberlain's Brook Formation (see Figure 5) is exposed in low sea cliffs that extend from the headland between Great and Little Dantzic Coves to the northern end of Little Dantzic Cove. This southerly-dipping sequence is separated into two sub-sections. The "Little Dantzic Cove section" (LDC, Stop 4) extends from member 3 of the Chapel Island Formation into the lowest part of the Random Formation (Figures 24, 25). The "Little Dantzic Cove Brook section" (LDC', Stop 5) includes the top of the Random Formation, the Brigus Formation, and most of the Chamberlains Brook Formation.

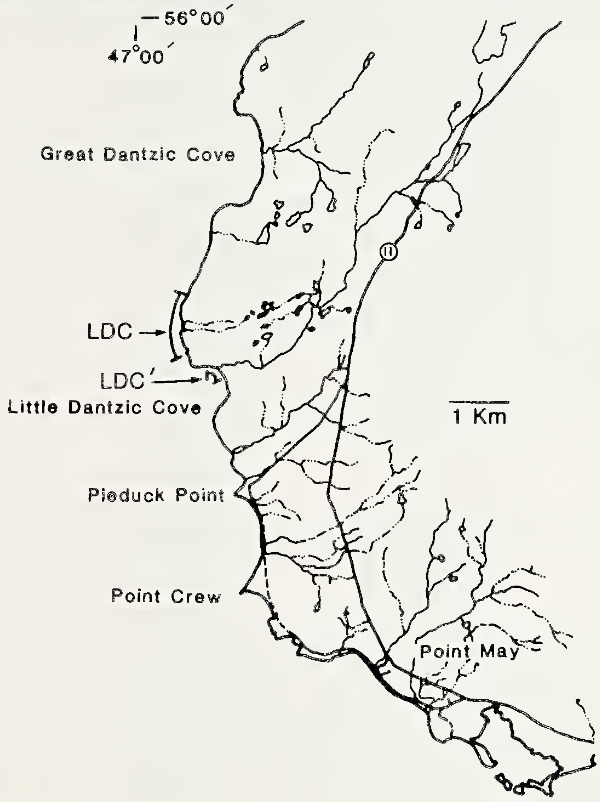


Figure 24. Generalized locality map of the Little Dantzic Cove (LDC) and Little Dantzic Cove Brook (LDC') sections, southern Burin Peninsula, southeastern Newfoundland.

The lower part of the LDC section is reached by a 3.5 km walk along sheep and cattle trails in meadows just inshore from the beach and cliffs. Two small synclines with sections from the uppermost Random Formation into the Chamberlains Brook Formation are exposed on the shore on the north side of the wharf and at the mouth of Snook's Brook (0.75 km north of the wharf). These sections have ben measured and sampled in a study of the microstratigraphy of the Brigus and Chamberlains Brook Formation (EL, unpub. data). Massive white orthoquartzites of the Random Formation dominate the sea cliffs north of Snook's Brook. A contorted section of Manuels River Formation (black shales) is exposed at low tide along the base of the cliffs (glacial drift) at the south end of Little Dantzic Cove. Further north, Little Dantzic Cove Brook occupies the axis of a syncline that includes strata as high as the Manuels River Formation (Hutchinson, 1962). The south limb of this syncline includes the Random Formation (forming the north end of Little Dantzic Cove) and the underlying Chapel Island Formation.

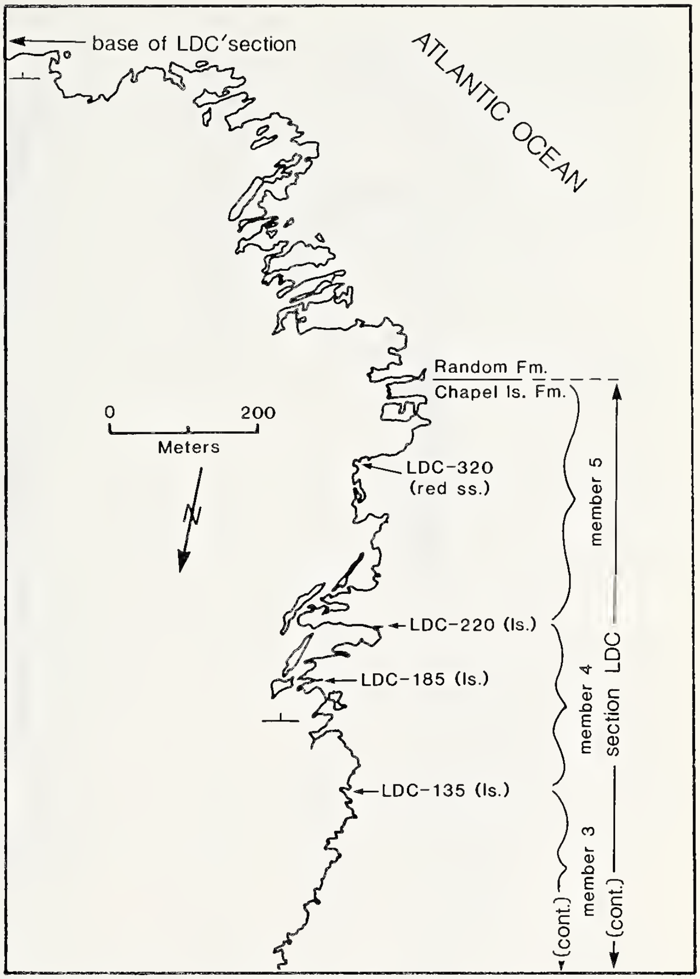


Figure 25. Detail map of the traverse from upper member 3 of the Chapel Island Formation through the lowest part of the Random Formation (Stop 4, LDC section). Base of section LDC' (uppermost Random Formation and Brigus through Chamberlains Brook Formations) shown at top of figure.

STOP 4A Upper member 3 and base of member 4 of the Chapel Island Formation (LDC-95 m to LDC-135.15) (EL, PM, GMN)

Description.—Upper member 3 is dominated by greenish, generally structureless (bioturbated), siliciclastic mudstones with very thin, fine sand laminae. Whitish to buff-weathering calcareous nodules are abundant and developed preferentially along horizons with the sand laminae. The sand laminae thicken abruptly as they pass into laminae and demonstrate the very early (precompactional) growth of nodules. Two cyclic alternations in (mudstone) color (green-to-purple and green-to-red) occur in uppermost member 3. Small calcareous nodules are abundant in the more oxidized (e.g. red/purple) mudstones of these cycles. The double limestone forming the top of member 3 is composed of coalesced diagenetic nodules and is abruptly succeeded by green shale. These cyclic changes in color also occur 40 km to the northeast at Fortune North (Fig-

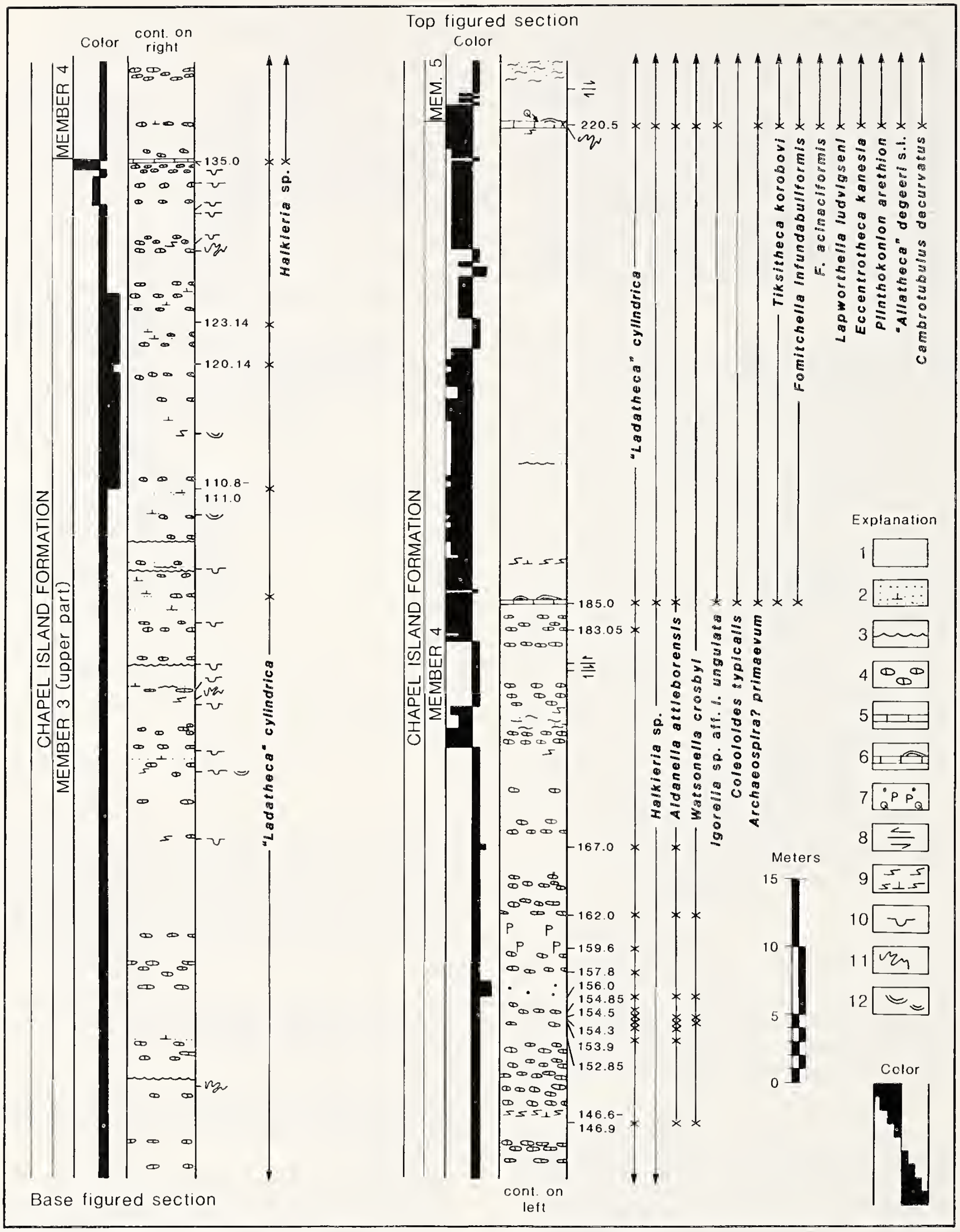


Figure 26. Section from upper member 3 into lower member 5 of the Chapel Island Formation at Little Dantzic Cove (Stops 4A-D). Explanation: 1, silty siliciclastic mudstone; 2, mm- to cm-thick, fine grained sand laminae (planar- to microcross-laminated) in lithology 1, locally calcareous or passing into small calcareous nodules; fine-grained sandstones and mudstones, thin bedded; 3, rippled surfaces; 4, calcareous (microsparite) nodules (commonly less than 10 cm-long X 5 cm-thick in red/purple mudstone, larger in green mudstone); 5, bedded limestones; 6, bedded limestones with stromatolitic (mud-cracked) and oncolitic parts; 7, pyrite (black) and phosphate (P) nodules, and sand- to pebble-sized quartz, re-worked volcanic, and argillite fragments (Q); 8, bedding plane shears/faults with quartz veins; 9, *Planolites*, locally calcite-cemented; 10, *Diplocraterion*; 11, *Helminthopsis*; 12, *Teichichnus*. Color symbol shows nine "steps" from upper left to lower right: red (upper left), purplish red, purple, purple with green streaks/ splotches, green with purple streaks/splotches (center line), green, dark green, dark greenish grey to grey, dark grey/black (lower right). Numbers to right of column give horizon (meters above base of section) of small shelly fossil collections.

ure 8) and provide a precise basis of correlation even though the top limestone bed of member 3 at Little Dantzic Cove is not present at Fortune North. The green shale directly overlying the limestone at this section is the base of member 4.

Upper member 3 represents low energy shelf environments. Rippled surfaces that often show a parting lineation due to aligned mica flakes suggest the episodic influence of slightly higher energy bottom current and wave activity. In general, the rate of burrowing activity exceeded accumulation rate and most primary sedimentary structures are not preserved.

Fossils.—Trace fossils are not very diverse because upper bedding surfaces, rather than soles, are exposed. *Diplocraterion* and *Teichichnus*, which appear lower in the *Rusophycus avalonensis* Zone, and *Helminthopsis* are present.

Almost every calcareous nodule horizon has been sampled for small shelly fossils. However, only several specimens of limonitized conchs of "*Ladatheca*" *cylindrica* were recovered at LDC-31.25 (29.75 below section in Figure 26). Rare specimens of "*L.*" *cylindrica* may be collected in the mudstones of interval LDC-104 m to LDC-123 m. These internal molds are regularly encountered only in the slightly darker green shale interval (110.8-125.5 m) and this suggests a facies control on their preservation (see Stop 4B). Equivalent strata at the Fortune North section have a more diverse small shelly fauna (*Watsonella crosbyi, Aldanella attleborensis,* "*L.*" *cylindrica*) in the upper 33 m of member 3 due to pyritization and preservation of calcareous remains that also occurred very early during compactional history at this section.

STOP 4B Pyritized small shelly faunas, lower member 4 of the Chapel Island Formation (LDC-146 m to LDC-167 m) (EL, PM, GMN)

Description and fauna.—*Watsonella crosbyi, Aldanella attleborensis,* and "*Ladatheca*" *cyclindrica* are abundant as pyritized specimens at a number of horizons in this interval (see Figure 26). *In situ* specimens of "*Ladatheca*" (apex down) and *Watsonella* (umbo up) indicate that this assemblage of fossil species lived on greenish mud bottoms. Many of the specimens are found distorted in the green shales and in the (early compactional stage) calcareous nodules. This indicates a diagenetic history including a) early dissolution of (presumably) aragonitic conchs, b) pyritization of remnant shells during compaction, c) nodule formation, d) continued compaction.

This stop emphasizes that the lowest occurrence of small shelly fossils in Avalon is, in part, diagenetically controlled.

STOP 4C Small shelly fossil diversity and environmental control (LDC-185 m) (EL, PM, GMN)

Description.—The second bedded limestone at section LDC is a ca. 15 cm-thick, red-colored bed with a complex internal structure. The lower third to half is a microsparite that is a probably diagenetic "underbed" while the upper part is a fossil (dominantly "*Ladatheca*") wacke- to packstone. Several deeply embayed surfaces in the upper part of this wack- to packstone are coated with limonite-impregnated, stromatolitic laminae. The upper surface of the bed has limonitic oncolites and a limonitic crust.

Faunas.—Several genera (*Coleoloides, Archaeospira*?, *Fomitchella*) have their lowest appearance while *Halkieria* becomes abundant in this limestone. The sudden "diversification" of the small shelly faunas in this bed is simply an immigration event. The animals of the fauna have "tracked" a very shallow water limestone habitat that appeared in this section as a result of probable offlap.

At the end of the stop, climb the shore cliff and walk upsection past a reddish shale-dominated interval to LDC-220.

STOP 4D Faunal diversity and limestones, shoal water phenomena (*redux*) (LDC-220) (EL, PM, GMN)

Description.—The thick (0.5-0.8 m) limestone unit (base at 220 m) is the uppermost part of member 4. It is abruptly overlain by green shales and fine-grained sands of member 5 (Figure 26).

The limestone unit features some of the same developments seen at LDC-185. The lowest part of the unit is probably an underbed produced during early diagenesis by the growth of coarse calcite (pseudospar) and displacement of a red siliciclastic mud. The pseudospar post-dates the erosive events recorded by the immediately overlying carbonate and siliciclastic mudstone pebble lenses in the lower part of the unit. These lenses are overgrown by desiccation-cracked, planar stromatolites in the middle part of the unit. The upper part of the unit includes a fossil (orthothecid and "*Ladatheca*") wackestone overlain by another layer of planar stromatolites. This layer shows desiccation cracks, sheet cracks and teepee structures. A fossil wackestone forms the highest part of the unit except where broad algal mudmound domes (bioherms) rise above the general upper surface of the unit (Myrow, 1987).

Fossils.—The higher diversity, small shelly fauna recovered at LDC-185 re-appears in this unit with the re-establishment of very shallow water conditions indicated by the sedimentary features of the bed. Persuasive evidence for the association of this limestone with offlap is provided by the land-derived coarse sand-to pebble-sized clasts of quartz and volcanic rock in the upper stromatolitic part of the bed (Myrow, 1987). The long, relatively unbroken conchs of orthothecids and "*Ladatheca*" from this unit indicate limited transport. All of these features suggest a very near shore habitat for the fauna.

Following a brief examination of the lowermost part of member 5, continue up-section.

STOP 4E Middle part of member 5 of the Chapel Island Formation (LDC-250 m to LDC-307 m) (PM, GMN)

Description.—The strata (Figure 27) include green to dark grey, thin- to medium-bedded sandstones and siltstones and minor laminated shales. The sedimentary structures are difficult to see and are little enhanced by weathering. Bed thickness increases upward in this interval, and the most common sedimentary structure is parallel-lamination in sandstone. These sandstones were deposited on the open shelf below the influence of storm waves.

Fossils.—Fossils are not common because soles and upper bedding surfaces are poorly exposed. The trace fossils include *Helminthopsis abeli, Helminthoida* cf. *crassa, Cosmorhaphe*? sp., *Muensteuria* sp. and *Teichichnus rectus* from the *Rusophycus avalonensis* Zone. Other forms, such as *Paleophycus tubularis, Planolites montanus* and *P. beverlyensis*, occur in lower ichnofossil zones.

STOP 4F Transition from middle to upper part of member 5 of the Chapel Island Formation (LDC-310 m to LDC-317 m) (PM, GMN)

Description.—Thin to medium bedded, parallel-laminated sandstones and slightly calcareous, orange-weathering, bioturbated siltstones (Figure 27). This transition zone contains a few hummocky cross-stratified sandstone beds that imply shallowing and storm wave reworking of the sea floor.

Fossils.—The siltstones are bioturbated. Recognizable burrows in the sandstones include *Teichichnus rectus*, *Planolites montanus* and *P. beverlyensis*.

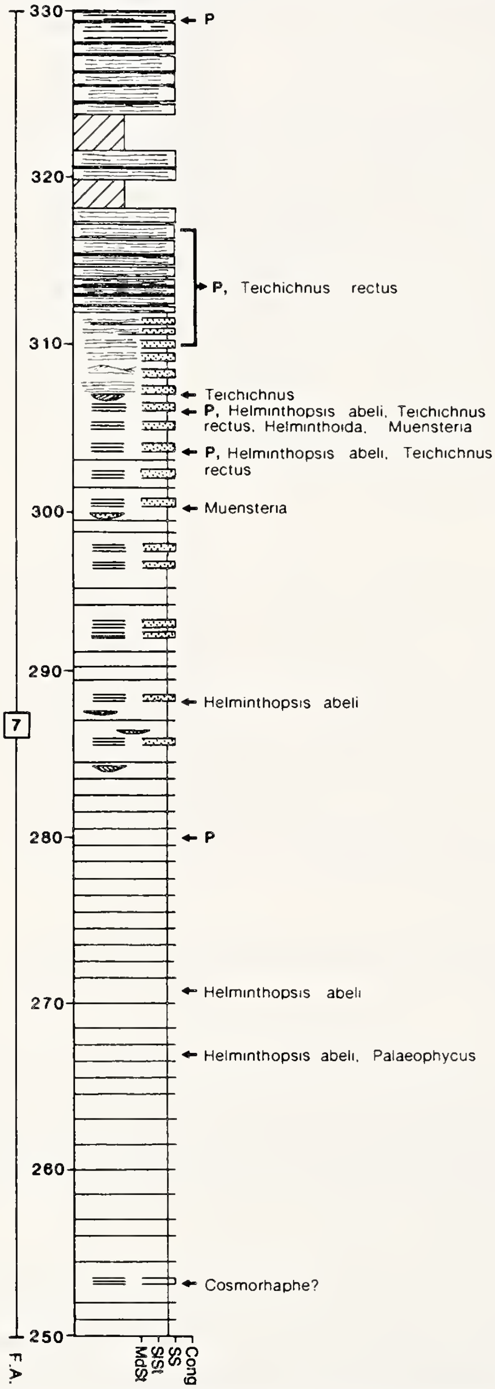

330
P
320
P, Teichichnus rectus
310
Teichichnus
P, Helminthopsis abeli, Teichichnus rectus, Helminthoida, Muensteria
P, Helminthopsis abeli, Teichichnus rectus
300
Muensteria
290
Helminthopsis abeli
7
280
P
270
Helminthopsis abeli
Helminthopsis abeli, Palaeophycus
260
Cosmorhaphe?
250
F.A.
MdSt
SlSt
SS
Cong

Figure 27. Middle and upper parts of member 5 of the Chapel Island Formation (Stops 4E and 4F).

STOP 4G Upper part of member 5 of the Chapel Island Formation (LDC-330 m to LDC-352 m) (PM, GMN)

Description.—Medium to thick bedded, red micaceous sandstones and thin interbeds of bioturbated shaly siltstone. Bed thicknesses increase upward within this part of the section (Figure 28). The sandstones are hummocky cross-stratified and represent deposition along a storm- and wave-dominated shoreline at depths between storm and fair weather wave base.

Fossils.—An upper surface of a sandstone at LDC-331.9 has *Diplocraterion* and other paired vertical burrows. Another surface at LDC-336.5 shows *Taphrhelminthopsis* sp. and *Uchirites*? sp. *Palaeophycus tubularis* and *Planolites beverlyensis* occur on these and other surfaces.

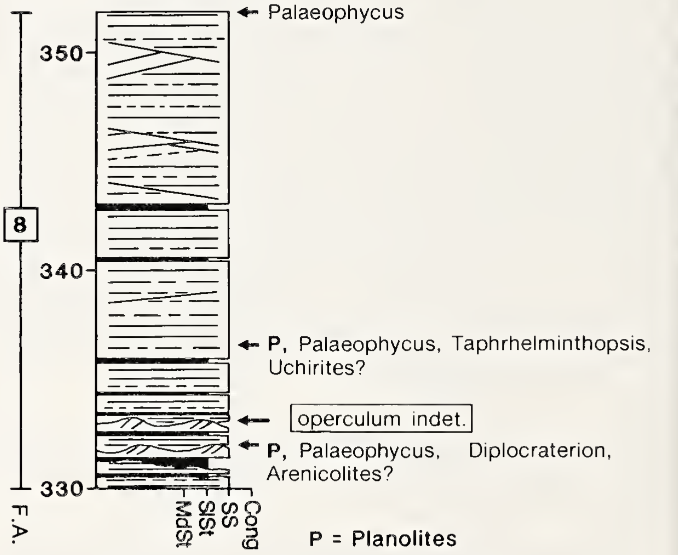

Palaeophycus
350
8
340
P, Palaeophycus, Taphrhelminthopsis, Uchirites?
operculum indet.
P, Palaeophycus, Diplocraterion, Arenicolites?
330
F.A.
MdSt
SlSt
SS
Cong
P = Planolites

Figure 28. Upper part of member 5 of the Chapel Island Formation (Stop 4G).

STOP 4H Lower part of the Random Formation (PM, GMN)

Description.—The lower part of the Random Formation is dominated by red micaceous sandstones identical to those in the upper part of member 5 of the Chapel Island Formation. However, the Random has intervals of quartzarenitic sandstones and thin shales. The lower part of the formation represents a transition from storm- and wave-influenced deposition (red hummocky cross-stratified sandstones) to deposition under the influence of strong tidal currents (white quartzarenitic sandstones of the upper part of the Random Formation).

Fossils.—A wide variety of trace fossils have been reported from the Random Formation by Crimes and Anderson (1985). They reported *Arenicolites* sp., *Diplocraterion* sp., *Scolicia* sp., *Skolithos* sp., *Helminthopsis abeli* and *Planolites beverlyensis* from Little Dantzic Cove.

At the end of the stop, walk south to Little Dantzic Cove.

STOP 5 Little Dantzic Cove Brook (LDC'), Brigus and Chamberlains Brook Formations (EL)

The stop is representative of post-Random Lower Cambrian (Brigus Formation) and lower Middle Cambrian (Chamber-

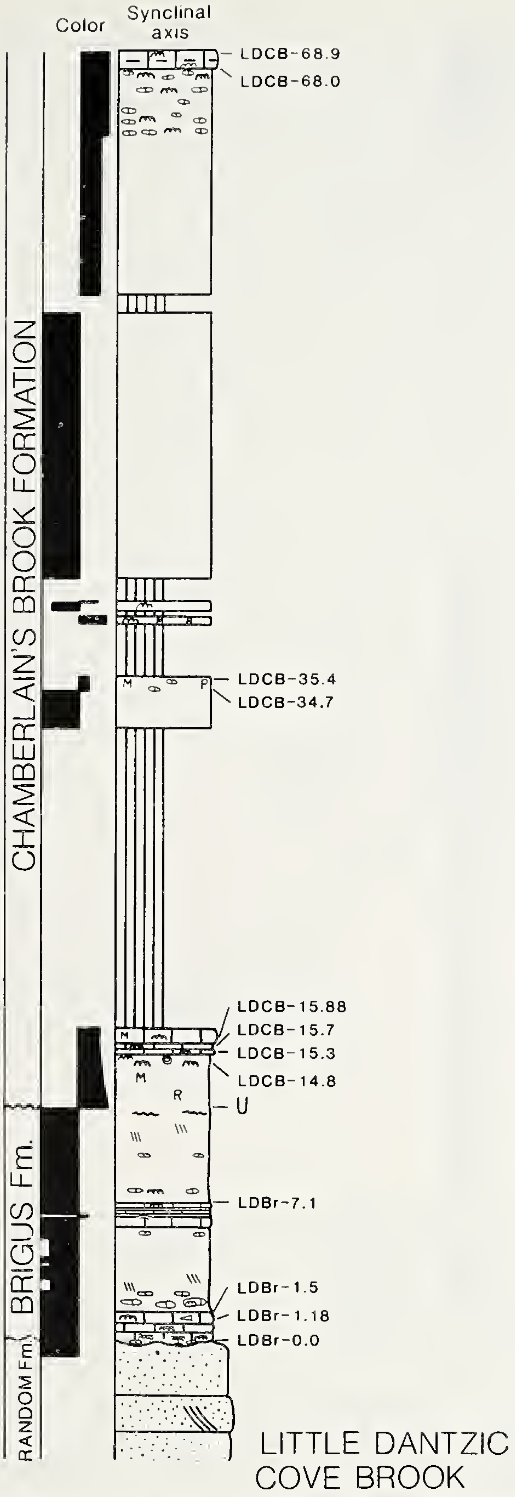


Figure 29. Section from the upper part of the Random Formation through the Chamberlains Brook Formation, northwest corner of Little Dantzic Cove (Stop 5). Explanation: Symbols and color descriptor after Figures 14 and 31; vertical ruling (= covered interval); M (manganse oxide grains, nodules and (on limestones) crusts); R (rhodochrosite nodules); brachiopod symbol at LDCB-15.2); elongate "U"-shape is *Arenicolites*; wave ripples indicated in lowest Chamberlain's Brook Formation. Sample horizons (i.e. LDCB-7.1) indicate distance above Random-Brigus formational contact.

lains Brook Formation) stratigraphy in the southwestern part of the Burin Peninsula. The section (Figures 25, 29) extends from the top of the Random Formation on the north side of Little Dantzic Cove to the outlet of Little Dantzic Cove Brook. The section is best exposed at low tide after storms have swept away the beach cobbles.

Although only a small amount of relief (ca. 15 cm) is present at the Random-Brigus contact, this is a major unconformity; the sub-trilobitic Bonavista Group and much of the lower *Callavia* Zone s.l. as known elsewhere in the Brigus Formation are absent at the contact. The Brigus-Chamberlains Brook contact lies only 12.3 m above the Random Formation and is marked by the base of *Arenicolites*- and rhodochrosite nodule-bearing brown-grey shales. This red-brown shale contact is a cryptic unconformity with the upper Brigus and much of the lower Chamberlains Brook Formation, as known elsewhere, is not represented.

The Brigus Formation reaches a thickness of 220 m in Trinity Bay (Hutchinson, 1962), and Little Dantzic Cove lies near the unit's western feather-edge. Unconformable upper and lower contacts and the possibility that a considerable amount of time may be represented in the glauconitic, phosphatized limestones with numerous hard grounds in the lower part of the section (0.15-1.54 m) both contribute to local thinning of the Brigus.

Shelly fossils in the lower beds of the Brigus include species that persist from sub-trilobitic strata (*Coleoloides typicalis*, *Sunnaginia imbricata*, *Eccentrotheca imbricata*, *Camenella baltica*) and others seemingly limited to the trilobitic Lower Cambrian (linguellids, *Micromitra*) (Bengtson and Fletcher, 1983; EL, unpub. data).

A total of 57.75 m of the Chamberlains Brook Formation (Middle Cambrian) is exposed in discontinuous shore outcrops. The limestone unit exposed at the top of the section at the outlet of Little Dantzic Cove Brook lies only several meters below the overlying Manuels River Formation. The red, green, and dark grey siliciclastic mudstones of the Chamberlains Brook Formation are typically structureless (e.g. burrow homogenized) and contain abundant manganese carbonate or oxide nodules. Two of the three thick limestone intervals present in the Chamberlains Formation in the southwestern Burin Peninsula (see 15.3-16.6 m and 68.05-69.05 m; Figure 29) are exposed. The trilobite fragments in these limestones are often reoriented by burrowing activity. The tops of limestone beds are frequently manganese oxide crusts which show planar stromatolitic structure. The upper part of the formation becomes darker grey as it grades into the overlying Manuels River Formation.

At end of stop return to vehicles and drive to Marystown.

DAY 5

0.0	Depart from hotel and take Rte. 210 north to the Village of Goobies and the intersection with the Trans-Canada (Rte. 1).
144	Intersection with Trans-Canada, turn south (right) towards St. John's.
152	Intersection with secondary roads to the Villages of Sunnyside and Come-by-Chance, turn east (left to Sunnyside and drive through village.

157.5 Sunnyside (locality Su), park at east end of high, south-facing road cuts. Descend to beach through meadows and walk west along shore (ca. 200 m) to contact of Random Formation with the overlying Bonavista Group.

STOP 6 Sunnyside, sections in the Petley, West Centre Cove, and Cuslett Formations of the Bonavista Group (EL, APB)

The locality lies on the east limb of a northerly plunging syncline and is located on the north shore of Bull Arm fjord (Figure 4).

The contact of the Random Formation with the overlying Bonavista Group is an unconformity. The thick sandstones that form the top of the Random Formation at Hickman's Harbour and eastern Smith Sound (Hutchinson, 1962; Fletcher, 1972) are not present and the interbedded thin quartz arenites and greenish silt-shales seem to lie lower in the Random Formation. The greenish shales that form the top unit of the Random become reddish 0.75 m below the contact with the Bonavista Group and this may be a weathering profile. These shales are calcified at the contact and show subvertical, quartz sand- and carbonate-filled joint cracks that merge into horizontal fissures. These features suggest subaerial erosion and gentle extensional movements prior to deposition of the Bonavista Group.

The initial deposits of the Bonavista Group are arkosic fine-grained sandstones, lenticular conglomerates with fragments of re-worked upper Precambrian lithologies (volcanics, argillites), and interbedded algal mudmounds and nodular carbonates. These beds and an overlying 28 cm-thick interval of fossil wackestone and nodular carbonate represent the Petley Formation (here 3.5 m-thick), the lowermost formation of the Bonavista Group. The Petley Formation represents a peritidal environment. Five successive interchannel/tidal flat cycles (showing southwesterly flow) are observable in the cross-bedded sandstones in the upper part of the formation (3.35-4.0 m above contact). The uppermost limestones have an abundant *Aldanella*-hyolith fauna that appears with the deepening/onlap event just prior to shale deposition of the West Centre Cove Formation.

The type section of the West Centre Cove Formation extends as a long cliff along the shore. The base of the formation lies at the top of the limestone bed forming the top of the Petley Formation (3.5 m above Random Formation) and the top of the formation is defined at the top of the thick, double-limestone interval approximately 200 m-east along the shore (35.4 m above Random Formation). Although thicker outcrops of the West Centre Cove Formation are known (see Landing and Benus, this Bulletin), this section is completely exposed and accessible. Most of the West Centre Cove Formation at this locality consists of structureless (bioturbated) red and (less important) green shales with diagenetic calcareous nodules and nodular limestone beds. Chamosite, as scattered grains and late diagenetic rinds around the calcareous nodules, is a prominent feature in the West Centre Cove Formation. The limestone interval (34.0-35.4 m) at the top of the formation is divided into two beds by a ca. 20 cm-thick interval of green shale with nodular carbonate. The middle part of the upper limestone bed has limonite-impregnated, mud-cracked planar stromatolites and thin lenses of quartz arenite with shale fragments. These features suggest that an interval of maximum offlap and peritidal conditions are preserved in the bed. The upper half of the bed has an abundant *Aldanella*-hyolith fauna that accompanied the initial onlap just prior to deposition of shales of the Cuslett Formation.

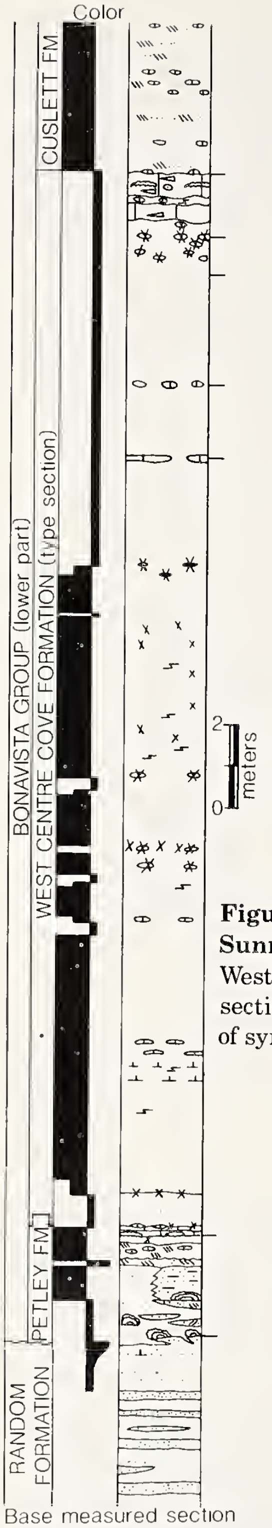

Color
CUSLETT FM
BONAVISTA GROUP (lower part)
WEST CENTRE COVE FORMATION (type section)
PETLEY FM
RANDOM FORMATION
2
0
meters
Base measured section

Figure 30. Lower part of the section at Sunnyside (Stop 6). This section in the West Centre Cove Formation is the type section of the formation. For explanation of symbols, see Figures 26 and 32.

A representative section of the Cuslett Formation extends from the top of the West Centre Cove Formation (35.4 m) along the west side of Centre Cove. Marker beds in the Cuslett Formation have been traced into the face of the road cut above the vehicle parking area, and the section continues across the hilltop to where it is covered (235 m above the Random) on the north-facing slope of the hill. The four informal members of the Cuslett Formation (Landing and Benus, this Bulletin) are recognizable on a traverse into West Centre Cove and across the hill top:

1) "member 1," a. red shales with mm to cm-thick, greenish, fine sands and small nodules (35.4-66.58 m), b. greenish mudstones with calcareous nodules, locally dark green to black and laminated (66.58-96.65 m), c. purple mudstones with small calcareous nodules (66.58-131.95 m), e. interbedded purple and red mudstones with small calcareous nodules in 0.5-1.0 m-thick cyclic alternations;

2) "member 2," red mudstones (locally purple) with nodular and bedded limestones, base drawn at base of lowest bedded limestone (131.95-154.5 m);

3) "member 3", purple mudstones (lower 7.5 m) transitional upward into purple and red mudstones with bedded limestones and nodular carbonates (154.5-201.66 m);

4) "member 4", purple mudstones with scattered small nodules and abundant *Teichichnus* traces (201.55-235 + m).

The base of "member 2" marks a key faunal change in southeastern Newfoundland. At this level *Coleoloides typicalis* becomes very abundant, *Camenella baltica* appears in the small shelly fauna, and the first hyolithids appear. The appearance of the *Camenella baltica* Interval (= "*Coleoloides typicalis* assemblage" interval of Bengtson and Fletcher, 1983) is solely a reflection of the appearance of widespread, shallow water, bedded carbonates.

At the end of the stop, return to vehicles and drive back to the Trans Canada.

163	Intersection with Trans-Canada, turn south (left) and proceed to motel at Whitbourne Centre.
235	Whitbourne Center.

DAY 6

0.0	Depart from motel and travel north on Trans-Canada to the City of Clarenville.
85	The overlook to the east across Northwest Arm fjord includes impressive views of the Upper Cambrian and Lower Ordovician black shales in the cliffs on Random Island.
94	Turn east (right) at interchange with Rte. 230 and proceed through Clarenville, continue on through the Villages of Milton and Georges Bank.
107	Intersection with Rte. 232, turn east (right) on Rte. 232 through the Village of Harcourt.
120	Village of Fosters Point, turn north (right) onto road leading (steeply!) downhill to the wharf, park vehicles.

STOP 7 Smith Point: top of the Bonavista Group and the unconformity at the top of the sub-trilobitic Lower Cambrian (EL, APB)

Stop 7 (see Figure 4) complements yesterday's traverse by showing higher strata of the Bonavista Group. This locality is the type section for the "Smith Point Limestone" of all previous reports. However, the "Smith Point Limestone" is a composite stratigraphic unit that has an important unconformity that separates sub-trilobitic limestone from overlying trilobite-bearing limestone. The latter beds are regarded as the initial deposits of the Brigus Formation onlap and are assigned to the Brigus Formation. To avoid confusion, a new name, "Fosters Point Formation," is proposed for the sub-trilobitic part of the "Smith Point Limestone."

The upper part of "member 4" of the Cuslett Formation at this locality is a green mudstone that becomes red at the base of a lenticular, nodular carbonate (Figure 31). The base of the Fosters Point Formation is defined at the base of the first bedded limestone (here locally an algal mud mound) which is thicker than the shales with which it is interbedded. The Cuslett-Fosters Point boundary is apparently conformable at this locality although local unconformity (Stop 10) is present in sections to the east.

The Fosters Point Formation (7.0 m-thick) consists of intercalated nodular-appearing limestone beds and interbeds of red siliciclastic mudstone with nodular limestone in its lower part. The nodular-appearing limestone beds form a "griotte" with red shale surrounding the "nodules." Most of these nodular bedded carbonates are probably algal mud mounds with stylolitized contacts with the surrounding shale. Shell hash (primarily *Coleoloides* tubes) often infills the depressions between the "griotte" nodules. Well defined algal mud mounds with *in situ Coleoloides* tubes radiating toward the margins of the mounds (see 130.6 m, Figure 31) are well developed in the upper part of the Fosters Point Formation at this and other localities. Hyolith-oncolite-intraclast beds appear at the top of the formation.

The top of the Fosters Point shows ca. 15 cm of erosional relief, and the oncolitic trilobite-wackestones of the lowest part of the Brigus Formation can be seen to pinch out against topographic highs on this surface. Although a number of reports (Fletcher, 1972; Bengtson and Fletcher, 1983) report trilobites from only the uppermost 30 cm of the "Smith Point Limestone," trilobites occur in the upper 1.3 m of limestone at this locality. These limestones mark the onlap of the Brigus Formation (emended).

At end of stop, return to vehicles and continue east on road to the Village of Clifton.

132	Intersection with gravel road (on right) leading to beach, the intersection lies ca. 1 km west of Clifton at the west end of road cuts in red mudstones of the lower part of the Bonavista Group; park vehicles and walk north to shore along gravel road.

STOP 8 Clifton: Bonavista Group and lowest part of the Brigus Formation (EL, APB)

Stop 8 (see Figure 4) complements Stop 6 by showing a somewhat thicker section through the formations of the Bonavista Group. The section lies in the east limb of a large, north-south trending syncline that extends south across Smith Sound to Random Island.

The contact of the Random Formation with the overlying Bonavista Group lies on the west bank of the stream below the gravel road. The uppermost limestone unit of the Petley For-

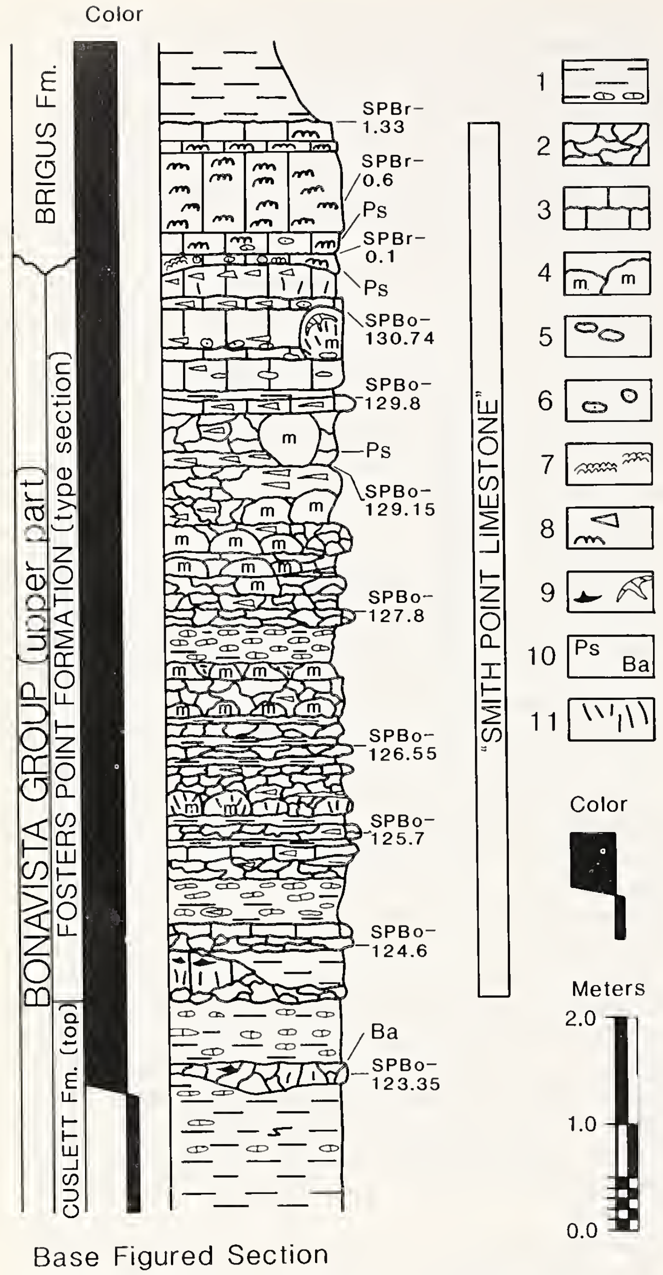


Figure 31. Type section of the Fosters Point Formation (Stop 7). Explanation: 1, siliciclastic mudstones, typically structureless (bioturbated) with calcareous nodules; 2, nodular limestone; 3, bedded limestones with stylolitic bedding contacts; 4, algal mud mounds in limestone; 5, intraclasts within limestone beds; 6, oncolites (frequently limonite-impregnated); 7, planar to "*Collenia*"-type stromatolites (frequently limonite-impregnated); 8, hyoliths (upper) and trilobites (lower); 9, birdseye structures (black symbol) and sheet cracks in mud mounds (right symbol); 10, bluish-weathering pseudospar (Ps) and barite crystals (Ba); 11, *in situ*, vertical tubes of *Coleoloides typicalis*. Color; red (left side) and green (right side). Sample numbers to right of column give distance (in meters) above base of exposed Bonavista Group (e.g. SPBo-130.74) and distance above base of Brigus Formation (emended) (e.g. SPBr-0.6).

mation lies on the west side of the road above a short green mudstone section that becomes red 1.0 mm below the limestones. The lower 35 cm of the limestone interval is composed of quartzose, fine-grained limestone in three beds. The upper 80 cm is a massive limestone bed showing fist-sized SH-V stromatolites at its base and an overlying oncolite-hyolith-*Aldanella* packstone. These beds (1.15 m-thick) are a thickened equivalent of the 0.5 m-interval of limestones at the top of the Petley Formation at Stop 6. The Petley Formation is 19.8 m thick in a completely exposed section to the southeast across Smith Sound at Petley (vs 3.5 m at Stop 6).

The overlying West Centre Cove Formation is exposed to the east in the cliffs and, as at Sunnyside, consists of chamositic red and green mudstones with calcareous nodules. The West Centre Cove Formation is thicker at Clifton than at Sunnyside (58.0 m vs 32.4 m) but has the same massive limestone interval at its top (1.0 m- vs 1.4 m-thick). Large wave-invaginated hyoliths are present in the limestone (Note fault duplication of the limestone in the cliff below the trees).

Approximately 61 m of the lower part of the Cuslett Formation are exposed along the shore cliff to the east. This section through "member 1" includes a sequence of red (lower part), green (middle) and purple (upper) mudstones comparable to "submembers 1a-c" at Sunnyside. Fifty meters of section are covered above the beach sections. However, the section can be continued up the hill in road cuts where upper "member 3" with its bedded red limestones in red shale is exposed (117.5-156.0 m above base of Cuslett Formation). "Member 3" is abruptly overlain by purple mudstones of "lower member 4" (156.0-183.6 m above Cuslett base), green, nodule-bearing mudstones of "middle member 4" (183.6-199 m) and red mudstones and bedded limestones of "upper member 4" (199-201.5 m).

The Fosters Point Formation (7.0 m-thick) and lowest trilobite-bearing limestone interval of the Brigus Formation (1.7 m-thick) form a low ridge that defines the east limit of the Village of Clifton. This sequence is nearly identical to that at Smith Point (Stop 7).

At end of stop, board vehicles and drive west.

159	Intersection with Rte. 230, turn north (right) and continue past intersections with roads to Lethbridge and Charleston.
196	Intersection with Rte. 235 at Village of Southern Bay, turn north (left) onto Rte. 235 and drive along cliffs facing Southern Bay.
236	Village of Kings Cove, turn north (left) onto road leading to the villages of Broad Cove and Keels.
240	Drive west through the "downtown" and park at west side of Keels at the head of the cove south of the government wharf. Walk to low, east dipping outcrops at southwest end of cove.

STOP 8A A Cambrian "worm" reef – algal mud mound association (EL, APB)

The north-plunging syncline at Keels (Figure 4) has the thickest known section through the Bonavista Group. Stop 8A lies in the west limb of the syncline.

The two limestone beds at this locality (Figure 32) the lateral equivalent of the double limestone bed that forms the top of the West Centre Cove Formation at Sunnyside and Clifton (Stops 6, 8). The limestone beds (114.2-115.85 m and 116.6-117.2 m above the base of the Bonavista Group) are separated by a shaly interval which is much more condensed at the latter localities.

The upper limestone bed is a relatively featureless pinkish-green, slaty microsparite with an undulatory upper surface. Although a slip cleavage has enhanced the relief on this upper surface, planar and digitate algal mats (limonite and silica impregnated) thicken and thin across high and low places, respectively, on the pinkish limestone. The pink limestone is probably a biostromal algal mud mound. The low places between the tops of the pink algal domes are packed with vertically embedded tubes of "*Ladatheca*" *cylindrica*. In addition, a

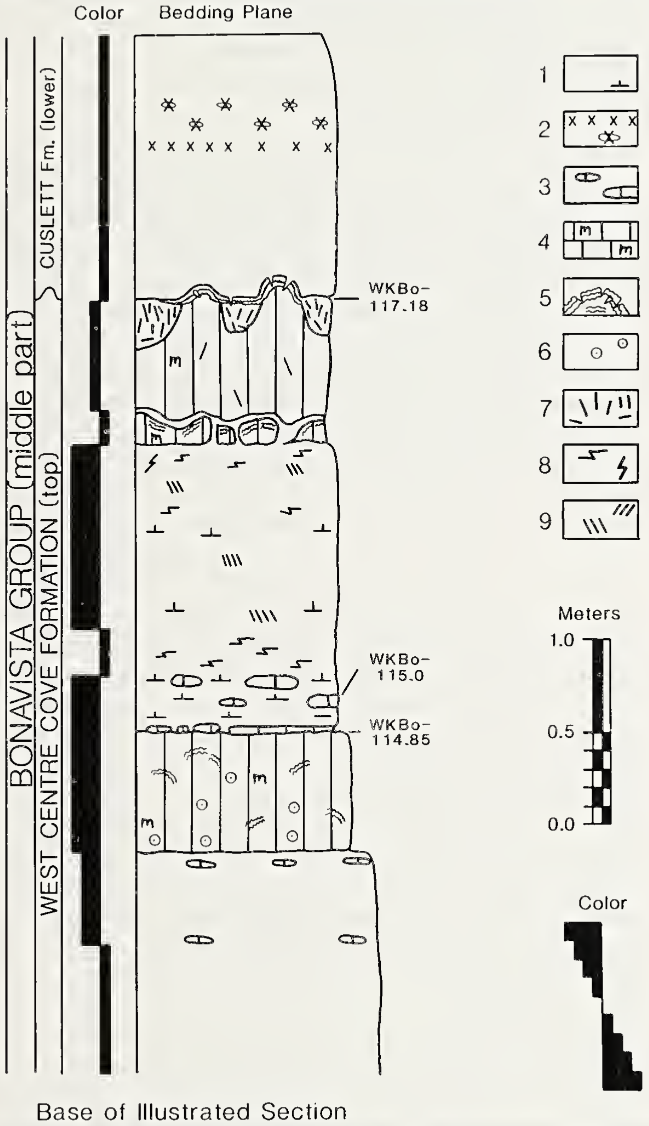


Figure 32. "*Ladatheca*"-algal mud mound association, top of the West Center Cove Formation, West Keels section (Stop 8A). Explanation: 1, siliciclastic mudstone, locally calcareous (lower-right symbol); 2, chamosite grains (×) and calcareous nodules with chamositic rind (lower); 3, calcareous nodules; 4, bedded limestone with algal mud mound (m) structures; 5, Fe/Si-impregnated stromatolite structures, locally dessication-cracked; 6, oncolites, limonite- and Fe/Si-impregnated; 7, *in situ* (vertical) and displaced (inclined to horizontal) conchs of "*Ladatheca*" *cylindrica*; 8, horizontal to inclined *Planolites*-type burrows; 9, small-scale cross bedding. Color designation as Figure 26. Sample horizons (i.e. WKBo-117.18) give distance (in meters) above Random Formation-Bonavista Group unconformity on west limb of syncline.

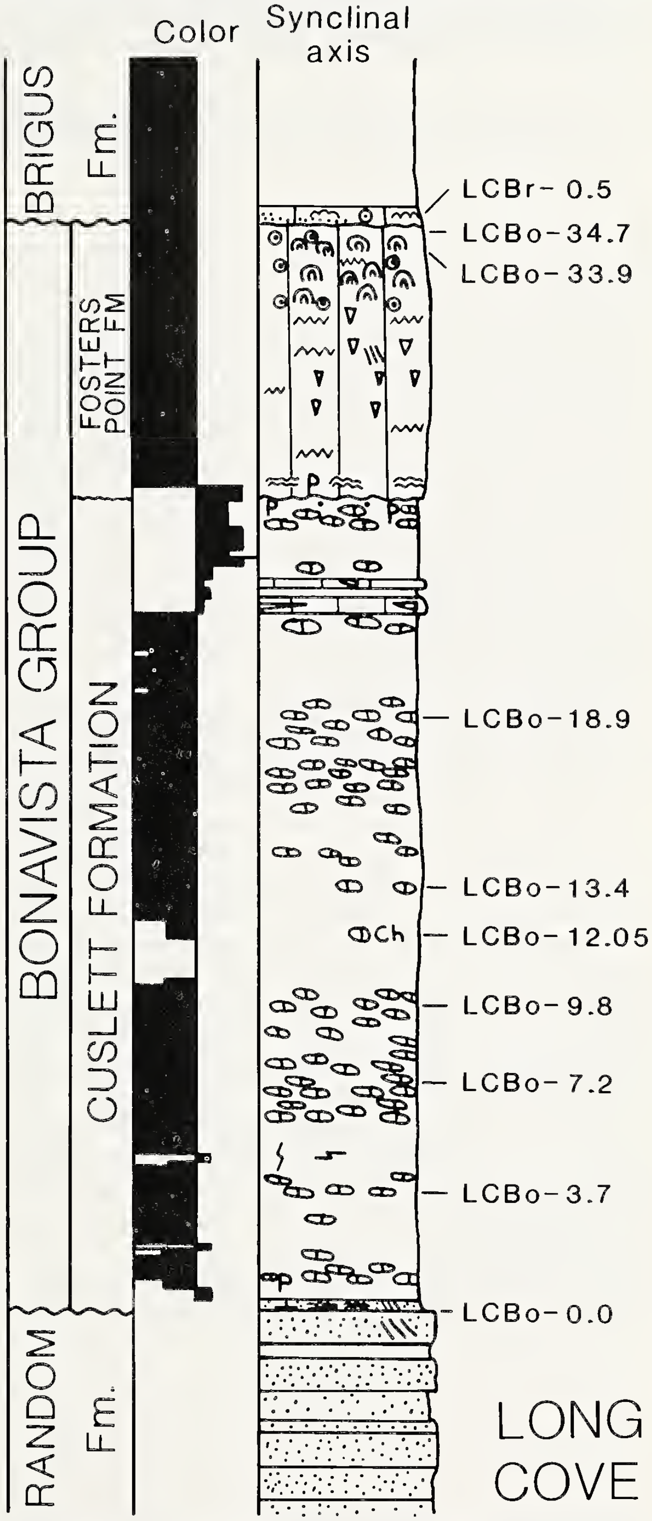


Figure 33. Section at Long Cove (Stop 9). Sample numbers to right of column give distance (in meters) above Random Formation.

few vertically embedded specimens occur within the pink limestone. The occurrence of *in situ Coleoloides* (Stop 7) and "*Ladatheca*" demonstrate that the typically Phanerozoic "worm reef" habitat had appeared by the very Early Cambrian. Vertically embedded "*Ladatheca*" conchs also occur in the top bed of the West Center Cove Formation on the east shore or Merasheen Island (locality Rr; Landing and Benus, this Bulletin). This locality is 160 km south-southwest of Keels.

At end of stop, return to vehicles and drive back through Keels, turn left into large gravel pit and park at north end. Walk north to end of peninsula and descend to shore.

STOP 8B Pelagic(?) hyoliths from the Cuslett Formation (EL, APB)

Several intervals of dark green to grey, pyritiferous shale occur in the upper part of the section in the east limb of the Keels syncline. These shales have allowed preservation of hyolith conchs by phosphatization or pyritization; in lighter green or red facies, these conchs were presumably dissolved away early in diagenesis. The interval 238-250 m and several other dark-colored intervals have vertically imbedded (aperture-down) hyoliths (Landing and Benus, In prep.). We are quite sympathetic to Dzik's suggestions that some "hyoliths" may be monoplacophorans and consider it likely that a pelagic or nektic life mode, similar to that of orthocone cephalopods had appeared by the very Early Cambrian.

If the tide is low, several *Aldanella*-orthothecid-phosphate pebble storm beds are accessible high in the section. The *Aldanella* shells are phosphatized in these lenses. Indeed, these are among the relatively few "phosphatic" remains found in the subtrilobitic Lower Cambrian in Avalon. In the course of this field trip, from southern Burin to Trinity Bay, we have observed that the dominant material used in conch construction was calcium carbonate (apparently aragonite). Avalonian Early Cambrian faunas have a few taxonomically problematical phosphate-secretors (tommotiids, tubes, *Microdictyon*, etc.) but these are also associated with calcareous problematica (halkierids, chancellorids). Taxonomic uniqueness, rather than mineralogic uniqueness, characterizes the earliest Cambrian skeleton-bearers. The case for a particularly high relative diversity of phosphate skeleton-builders in this interval seems to be based largely on work with secondarily phosphatized remains in Asian sections and laboratory techniques (acid disaggregation) that destroy the dominant calcareous component of the fauna.

At the end of the stop, return to vehicles and drive back on Rte. 235 and Rte. 230 to Lethbridge and the motel (ca. 75 km).

DAY 7

0.0	Depart from motel and return to Trans-Canada interchange in Clarenville.
22	Trans-Canada, turn south (left) toward St. John's.
107	Intersection with Rte. 202, turn north (left) on Rte. 202 and pass through Villages of Chapel Arm and Normans Cove.
116	Main intersection in Long Cove, drive north on gravel road along west side of bay.
118	Park vehicles, descend to shore.

STOP 9 Long Cove, unconformities bounding the Bonavista Group (EL, APB)

The purpose of Stop 9 (see Figure 5) is to highlight the unconformities in the "thin" Bonavista Group sequences that characterize southern and eastern Trinity Bays and Conception Bay.

Although several hundred meters of Bonavista Group strata occur in western Trinity Bay and the Bonavista Peninsula (Stops 6-8), only 33.7 m of section is present at this section (Figure 33). The Bonavista Group rests unconformably on the Random Formation. A 20 cm-thick calcareous quartz arenite with planar algal mats at its top is composed of reworked Random quartz sand. The overlying red mudstone-dominated sequence is the upper (and probably condensed) part of the Cuslett Formation. Several thick beds of hyolith-bearing, algal mud mound limestone near the top of the Cuslett Formation (22.25-23.55 m; see Figure 33) are laterally equivalent to the limestone-rich interval of upper "member 3" in the west Trinity sections. As at other localities on the eastern shore of Trinity Bay, these limestones are overlain by very dark, laminated shales (= "member 4") with pyrite crystals and phosphate nodules. The upper surface of these shales at the contact with the Fosters Point Formation shows 5 cm of relief and is phosphate impregnated. An erosional contact is suggested between the Cuslett and Fosters Point Formations.

The lower half of the overlying Fosters Point Formation is dominantly stylolitized algal mud mounds with abundant *in situ Coleoloides* and resembles the formation at Stop 7. However, limonitized oncolites and low SH-V domes are more abundant in the upper 1.9 m of the formation than at Stop 7 and suggest a nearer shore, higher energy environment (Landing and Benus, 1984).

These oncolitic limestones are overlain by a 0-8 cm-thick, cross-bedded quartz arenite marking the unconformity between the sub-trilobitic and trilobite-bearing Lower Cambrian. This thin sand and the overlying trilobite-rich, oncolitic limestone are assigned to the Brigus Formation and are part of the same depositional sequence as the overlying red shales.

At the end of stop, return to vehicles and travel to St. John's (110 km).

Radiometric dating of the Precambrian-Cambrian Boundary in the Avalon Zone

S. Conway Morris

Department of Earth Sciences
University of Cambridge

ABSTRACT

At present there is wide disagreement concerning the radiometrically-determined age of the Precambrian-Cambrian boundary. The once widely accepted figure of 570 myr has been challenged with claims for dates as old as 600 myr and as young as 530 myr. Evidence reviewed here tends to support the latter estimate in as much as a distinctive magmatic and volcanic episode in the Avalon Zone dated at about 600 myr is succeeded in south-east Newfoundland by a thick (ca. 13 km) sedimentary sequence. This includes a tillite and diverse Ediacaran biotas prior to the appearance of Cambrian shelly fossils and trace fossils.

INTRODUCTION

Although the search for the Precambrian-Cambrian boundary stratotype (Conway Morris, 1987) must use any source of data that might provide a distinctive marker with maximum potential for global correlation, in practice the definition is likely to hinge largely on biostratigraphy and perhaps chemostratigraphic events. Although existing uncertainties and inherent errors in radiometric dating suggest that, by themselves, absolute age determinations generally are too imprecise to be of widespread use in stratotype definition during the forseeable future, the resolution of some zircon dating (U-Pb method) appears to rival that obtainable by biostratigraphic means. Whatever method of radiometric dating is accepted as providing the most reliable dates, an acceptable date for the Precambrian-Cambrian boundary is important not only to establish its place in the Phanerozoic time-scale, but also for assessing the rates of change, especially of metazoan diversification, during this critical interval of earth history.

Although a date of about 560-570 myr for the Boundary (e.g. Cowie and Cribb, 1978) has become widely accepted, more recently this estimate has been seriously challenged so that claims now range from about 600 myr to 530 myr (see Cowie and Johnson, 1985). The former date obtained by Chinese workers, largely on the basis of Rb-Sr whole rock (sediment) determinations (see review by Cowie and Johnson, 1985), has been the subject of strong criticism (Odin *et al.*, 1985). At the opposite end of the spectrum, reports from western Europe, northern Africa and Sinai suggest that the Cambrian may be no longer than about 30 myr (e.g. Odin *et al.*, 1983; Odin *et al.*, 1985; see also Jenkins, 1984). Particular interest has recently focused on the Ercall Granophyre in central England (Shropshire) because it is closely associated with Lower Cambrian quartzites and has yielded a tight and apparently reliable isochron (Rb-Sr) of 533 ± 13 myr (Patchett *et al.*, 1980; see also Compston *et al.* in Cowie and Johnson (1985) who quote a figure of 531 ± 5 myr on the basis of U-Pb analyses of zircons). Debate about the nature of the contact between the granophyre and overlying sediments has now been resolved by Cope and Gibbons (1987) who have demonstrated an unconformity.

The Avalon Zone comprises a tectonic unit that encompasses south-east Newfoundland, together with Cape Breton Island and parts of mainland Nova Scotia, New Brunswick, Massachusetts and Rhode Island. There is a general consensus that it represents a superterrane (Williams and Hatcher, 1983; Keppie, 1985) that formed outboard of the Laurentian craton and was accreted during the middle Paleozoic. During the late Precambrian and Cambrian the Avalon Zone was probably relatively close to parts of Gondwanaland, such as northwest Africa and Armorica (e.g. Strong, 1979; Rast, 1980; Pique, 1981; King, 1982; Johnson and van der Voo, 1985; Seguin, 1985), and the striking similarities with the Cambrian successions of central England and southeast Newfoundland have been long recognized.

The Boundary successions in the Avalon Zone are reasonably well known, and particular attention is being paid at the moment to the sequence in the Burin peninsula because it is a viable stratotype candidate. Reviews of the various sections are available in a wide variety of literature, of which the papers by King (1980, 1982), O'Brien, Wardle and King (1983), and Rast and Skehan (1983) provide a suitable overview. More recently I have prepared a review of the Avalonian Boundary sequences (Conway Morris, submitted), and it is from this work that the following is culled.

The purpose of this brief report, therefore, is to survey the radiometric data for the Boundary sequences in the Avalon Zone. Where necessary, dates have been recalculated on the basis of the currently accepted decay constants (see Harland *et al.*, 1982), and some figures (especially for pre-1977 literature) should not be assumed to be those given by the original authors. Particular weight is given to the U-Pb determinations on zircons (e.g. Kaye and Zartman, 1980; Krogh *et al.*, 1983; Benus, this Bulletin), as these appear to provide the most reliable dates. In contrast, in at least some circumstances, Rb-Sr methods give somewhat unreliable dates (see Kaye and Zartman 1980, and also Dallmeyer *et al.*, 1981, p. 705). Accordingly, many of the other dates reviewed here must be regarded as being of more dubious validity. Such dates might require reassessment of existing data or, more importantly, re-analyses of samples. These latter dates are included as ancillary data and

South-east Newfoundland, Avalon Peninsula and Isthmus		South-east Newfoundland, northern Burin Peninsula		South-east Newfoundland, southern Burin Peninsula	
		Rencontre Formation	565±26[a]		
Bull Arm Formation	*584[a,b]				
Mistaken Point Formation	*565±3[c]	Love Cove Group (volcanics)	*590±30[e] *608±25[b,e]	Marystown Group (volcanics)	*$607.5^{+8.0}_{-3.7}$[d]
Harbour Main Group (volcanics)	*$585.9^{+3.4}_{-2.4}$[d] *$606^{+3.7}_{-2.9}$[d]				
Holyrood Granite	*590±11[e] *594±11[f] *610[g] *$620.5^{+2.1}_{-1.8}$[d]	Swift Current Granite	*580±20[e]		
Flemish Cap Granodiorite	*751-833[g]				

Nova Scotia Cape Breton Island		New Brunswick		Massachusetts and Rhode Island	
Fourchu Volcanics	?640[h]	Coldbrook Group (volcanics)	590[n] 640[o] 776±80[p]	Mattapan Volcanics	*602±3[q]
Various granites	548[i]			Northbridge Granite	553±10[r]
Capelin Cove Granite	545±28[h]			Dedham Granodiorite	595±17[s] *630±15[q]
Cheticamp pluton	525±40[j] *550±8[k]			Milford Granite	*619±5[t] *624±5[t]
Loch Lomand Granite	548±18[h] 544±21[l]			Narragansett granites	595[u] 603±14[v]
Shunacadie pluton	574±11[m]				
North Branch Baddeck River leucotonalite	*614^{+38}_{-4}[k]			Ten Rod Gneiss and Hope Valley Alaskite Gneiss	*601±5[w]
				Esmond Granite	*621±8[w]

Table 1. Summary of the principal radiometric dates from the late Precambrian of the Avalon Zone, excluding patently anomalous dates or original determinations that subsequently have been revised with changes in the decay constants. Sources of data: a, King, 1982; b, O'Driscoll and Gibbons, 1980; c, Benus, this Bulletin; d, Krogh *et al.*, 1983; e, Dallmeyer *et al.*, 1981; f, McCartney *et al.*, 1966; g, King *et al.*, 1985; h, Keppie and Halliday, 1986; i, Cormier, 1972, and Clarke *et al.*, 1980; j, Barr *et al.*, 1986; k, Jamieson *et al.*, 1986; l, Barr *et al.*, 1984; m, Poole, 1980a; n, Lowdon *et al.*, 1963; o, Leech *et al.*, 1963; p, Cormier, 1969; q, Kaye and Zartman, 1980; r, Gayle, 1982; s, Kovach *et al.*, 1977; t, Zartman and Naylor, 1984; u, Skehan and Murray, 1980; v, Smith and Giletti, 1978; w, Hermes and Zartman, 1985.

also to provide a historical review of age determinations in the Avalon Zone. Table 1 summarizes the data that appear to be more-or-less reliable.

RADIOMETRIC DATES

Southeast Newfoundland

Particular attention has been paid to the Holyrood Granite exposed at the southern end of Conception Bay on the Avalon Peninsula. It intrudes volcanics of the Harbour Main Group and is unconformably overlain by sediments of the Bonavista Group (McCartney *et al.*, 1966) that contain a Cambrian shelly fauna (Bengtson and Fletcher, 1983). The general consensus (e.g. McCartney *et al.*, 1966; Hughes and Brückner, 1971; but see Strong and Minatedis, 1975) is that the granite is comagmatic beneath the volcanics, and pebbles with a similar composition to the Holyrood Granite occur in conglomerates of the Conception Group. Gale (1982) revised the original determinations of McCartney *et al.* (1966), who used Rb-Sr whole rock measurements to give an estimate of 585 ± 15 myr, although a recalculation of the McCartney *et al.* (1966) value, using the accepted decay constant, gives a figure of 594 ± 11 myr (cf. Dallmeyer *et al.*, 1981, recalculated value of 590 ± 11). However, of more significance is an abstract by Krogh *et al.* (1983), who gives a substantially older date for the Holyrood Granite of 620.(+ 2.1, -1.8) myr on the basis of U-Pb analyses of zircons. Using the same method, King *et al.* (1985) published a date of 610 myr for these rocks.

Other radiometric determinations from igneous rocks in southeastern Newfoundland include Rb-Sr whole rock dates of 556 ± 29 myr and 483 ± 30 myr for the Harbour Main and Bull Arm Volcanics (Fairbairn *et al.*, 1966; values were also recalculated by McCartney *et al.*, 1966), although these are anomalously young and, in the case of the Bull Arm volcanics, probably are a reflection of the extensive metasomatism (Hughes and Malpas, 1971). However, O'Driscoll and Gibbons (1980; see also King, 1982, p.103) indicate a minimum U-Pb (zircon) date for these latter volcanics of 584 myr. More significant, therefore, is the dating of an ignimbrite in the Harbour Main Group (James Cove) at 606(+ 3.7, –2.9) myr, while an intrusive rhyolite dyke cutting these volcanics gave a date of 585.9(+ 3.4, –2.4) myr (Krogh *et al.*, 1983). This latter date is, of course, closely similar to some estimates of the nearby Holyrood Granite (see above), and considerably younger than some earlier estimates (e.g. Anderson, 1972).

Dating of zircons (U-Pb determination) from a tuff that overlies one of the Ediacaran assemblages in the Mistaken Point Formation gives a date of 565 ± 3 myr (Benus, this Bulletin). This formation occurs at the top of the Conception Group, and its dating is of particular relevance to the discussion of the age of Ediacaran biotas (see Jenkins, 1984).

For the Love Cove Group volcanics, which are probably correlative with the Harbour Main Group to the southeast, dates of about 608 ± 25 myr and 590 ± 30 myr (U-Pb age on zircons) were obtained by O'Driscoll and Gibbons (1980) and Dallmeyer *et al.* (1981). Furthermore, for the Swift Current granite that intrudes these volcanics, these latter authors obtained a revised date of 580 ± 20 myr. Thus, while this granite is analogous in setting to the Holyrood Granite, its lack of overlap in age in terms of U-Pb analyses of zircons suggests that it is somewhat younger. A U-Pb date of 607.5(+ 8.0, –3.7) myr (Krogh *et al.* 1983) for the Marystown Group on the Burin Peninsula also suggests a possible equivalence with the Harbour Main assemblage and Love Cove Group volcanics. A K-Ar date of 565 ± 26 myr has been given by King (1982) for the Recontre Formation. Finally, it is worth noting that a granodiorite exposed on Flemish Cap, about 500 km east of the Avalon Peninsula, may be substantially older than the onshore plutonic bodies such as the Holyrood and Swift Current granites. Pelletier (1971) published a K-Ar age from biotite of 615 ± 20 myr (recalculated by King *et al.*, 1985), but these latter authors obtained an age range of 751-833 myr on the basis of U-Pb analysis of zircons (King *et al.*, 1985). Younger ages ranging from 505 ± 48 to 657 ± 29 myr from K-Ar measurements of hornblende were interpreted as reflecting some resetting by very low metamorphism.

Massachusetts and Rhode Island

Elsewhere in the Avalon Zone, attention has focused on the Hoppin Hill granite (North Attleboro) and nearby igneous bodies that are believed to be contemporaneous. Dates obtained by Fairbairn *et al.* (1967) on the basis of Rb-Sr whole rock analyses were recalculated by Gale (1982) who considered only the Northbridge granite to be sufficiently reliable. This computation gives a revised date of 553 ± 10 myr. However, for the Dedham Granodiorite Kovach *et al.* (1977) obtained a date of 595 ± 17 myr on the basis of Rb-Sr whole rock measurements, while Kaye and Zartman (1980; see also Zartman and Naylor, 1984) quote a figure of 630 ± 15 myr on the basis of U-Th-Pb analysis of zircons; these data were omitted from consideration by Gale (1982). Zartman and Naylor (1984) also obtained radiometric analyses for a series of adjacent plutons, including the Milford Granite, and obtained broadly comparable ages of ca. 620 myr (Table 1). The Dedham Granodiorite is adjacent to the Mattapan Volcanics, but their precise interrelationships appear to be complex. In places the volcanics lie unconformably on the granodiorites (LaForge, 1932; Billings, 1979; Skehan and Murray, 1980), but Kaye and Zartman (1980) also presented evidence for possible intergradations. However, the radiometric dating of a rhyolite from the Mattapan Volcanics by Kaye and Zartman (1980) gave an age of 602 ± 3 myr (U-Th-Pb analyses of zircons) and suggests that these volcanics may be slightly younger than the adjacent plutonic rocks. If the dates of Kaye and Zartman (1980) and Zartman and Naylor (1984) are accepted, this suggests this Precambrian volcanic/plutonic sequence may be coeval with the Harbour Main Group and Holyrood Granite of southeast Newfoundland. Finally, it is worth noting that Precambrian granites intruding volcanics in southern Narragansett Bay, Rhode Island have a similar date of 603 ± 14 myr on the basis of Rb-Sr whole rock determinations (Smith and Giletti, 1978; dated as 595 myr in Skehan and Murray (1980), but details of procedure not given). These outcrops are close to sediments that are the putative equivalents of the Lower Cambrian successions at Weymouth and Hoppin Hill (Webster *et al.*, 1986). Moreover, intrusive bodies to the north (Esmond Granite and related rocks) and west (Ten Rod Granite Gneiss and Hope Valley Alaskite Gneiss) of Narragansett Bay also yielded comparable dates of 621 ± 8 myr and 601 ± 5 myr, respectively, on the basis of U-Th-Pb analyses of zircons (Hermes and Zartman, 1985).

New Brunswick

Rb-Sr whole rock dating of Coldbrook Group volcanics (Precambrian) in New Brunswick has given anomalously young ages (Fairbairn *et al.*, 1966). However, Cormier (1969) calculated the age of the Coldbrook Group on the basis of Rb-Sr whole-rock analyses to be 776 ± 80 myr, although Rast *et al.* (1976, p.319) regarded this as "rather doubtful." On the basis of granite pebbles from a conglomerate within volcanics on Ross Island, adjacent to Grand Manan Island, that are tentatively correlated with the Coldbrook Group, K-Ar dates on muscovites gave ages of 590 myr and 640 myr (Lowdon *et al.*, 1963, p.113; Leech *et al.*, 1963, p.103-104). Moreover, granites and other igneous rocks that intrude the Coldbrook Group (and Greenhead Group) may well be Precambrian (see O'Brien *et al.*, 1983, p.205) and contemporaneous with the Coldbrook volcanics (Currie, 1986). Poole (1980b) reported unpublished data of W. J. Olszewski and H. E. Gaudette that gave a Rb-Sr date, apparently from the Musquash pluton near Ludgate Lake, of 615 ± 37 myr, but subsequently these latter authors published a date of 392 ± 55 myr on the basis of RbSr whole rock determinations (Olszewski and Gaudette, 1982). They acknowledged, however, that this could be a re-set date, and that zircon analyses were more likely to provide the true age. Moreover, Poole's (1980b) own analysis (Rb-Sr, whole rock) of this intrusive body gave a date of 439 ± 17 myr while comparable analyses pooled from three adjacent granites (Chance Harbour, Lepreau and Red Head plutons) indicated a Cambrian age (526 ± 13 myr). O'Brien *et al.* (1983) noted that these, therefore, could be contemporaneous with the nearby volcanics of Cambrian age (see above), but Poole (1980b) preferred to conclude that the actual date of intrusion was probably late Precambrian and possibly comagmatic with the Coldbrook volcanics. In any event until reliable analyses based on zircons are available, all these dates from New Brunswick should be treated with great circumspection.

Cape Breton Island and mainland Nova Scotia

Some dates obtained from the Fourchu Volcanics (Cape Breton Island), which may be more or less conformable with the overlying Cambrian (Weeks, 1954), are anomalously young (Fairbairn *et al.*, 1966). More recently, Keppie and Halliday (1986) suggested a possible date of ca. 640 myr on the basis of Rb-Sr whole rock determinations. However, their data show considerable scatter, and they conceded that this date "should be viewed with caution." If accepted, this would suggest that the Fourchu Volcanics are considerably older than many of the other Avalonian extrusives considered here and could be equivalent to the Coldbrook Volcanic Group (see Keppie, 1982). A series of granites on Cape Breton Island, regarded as late Precambrian to Cambrian gave a series of dates (Rb-Sr determinations on both whole rock and minerals) of around 548 myr (Cormier 1972). Using the decay constant of ^{87}Rb accepted here, two granites (Capelin Cove and Loch Lomond) that cut the Fourchu Volcanics were dated as 545 ± 28 and 548 ± 18 myr (Clarke, Barr and Donohoe, 1980; Keppie and Halliday, 1986). Similarly, Barr *et al.* (1984) quoted a Rb-Sr date of 544 ± 21 myr from the Loch Lomond pluton. In addition Barr *et al.* (1986) obtained a new date (Rb-Sr whole rock) for yet another granite (Chéticamp) of 525 ± 40 myr that indicates a possible Cambrian age, although they also questioned whether this granite could be included in the Avalon Zone (see also Barr and Raeside, 1986). Furthermore, from U-Pb dating of zircons, Jamieson *et al.* (1986) obtained a date for the Chéticamp intrusion of 550 ± 8 myr while the North Branch Baddeck River leucotonalite was dated as 614 ± 38 myr by these workers. Poole (1980a) also presented evidence (Rb-Sr whole rock) that some of these Cape Breton Island granites, including the Shunacadie pluton (574 ± 11 myr), were definitely pre-Middle Cambrian and were probably intruded at a time close to the Precambrian-Cambrian boundary.

Granites from mainland Nova Scotia in the Cobequid Highlands also yield comparable dates using Rb-Sr whole rock techniques. Thus, the McCallum Settlement granite is dated at about 575 ± 22 myr (Gaudette *et al.*, 1983; see also Donohoe *et al.*, 1986), but the nearby Debert granite gives a date of 596 ± 70 myr (Donohoe *et al.*, 1986) that is too imprecise to be of much use in this discussion. Although a variety of dates are obtained from hornblende and micas (K-Ar techniques), the Jeffers Brook Diorite also appears to be of comparable age (Wanless *et al.*, 1974; Donohoe *et al.*, 1986). In terms of the age of the surrounding rocks intruded by these plutons, Donohoe *et al.*, (1986) point out that the sediments adjacent to the Debert granite, previously referred to the Nuttby Formation of early Carboniferous age, could be either late Precambrian or Cambrian and equivalent to the Warwick Mountain Formation and/or Jeffers Formation. Similarly, Wanless *et al.* (1974) inferred an age of either late Precambrian or earliest Cambrian for the volcanics intruded by the Jeffers Brook Diorite.

In conclusion, these dates from Nova Scotia remain of uncertain validity. The few zircon analyses (Jamieson *et al.*, 1986) are probably more accurate, and future work in this area should refine our understanding.

Carolina Slate Belt

Although this review has concentrated on the Avalon Zone, in this context reported dates from the Carolina Slate Belt may be also of some relevance. Pyroclastics that appear to be more or less equivalent to beds containing metazoan imprints have been dated as 620 ± 20 myr (U-Pb, zircons), while nearby granodiorites yield a date of 575 ± 20 myr (Cloud *et al.*, 1976). More recently, U-Pb (zircon) dates of 586 ± 10 myr (Uwharrie Formation) and 552 ± 7 myr (Yadkin Formation) that respectively lie below and above an Ediacaran fauna have been published (Wright and Seiders, 1980; Gibson *et al.*, 1984). The Caroline Slate Belt is also interpreted as an exotic terrane, but earlier suppositions that it should be treated as an extension of the Avalon Zone are now regarded as less likely (Secor *et al.*, 1983). Nevertheless, these dates and their association with Ediacaran faunas are broadly in accord with the data provided above.

CONCLUSION

To summarize, radiometric work from across the Avalon Zone points strongly to an igneous episode marked by volcanic activity and acidic intrusions dated at about 590-620 myr. The complexities of igneous activity over a protracted geological period may account for some of the scatter in dates, but it must be admitted also that a number of analyses may be suspect. Special importance is placed here on U-Pb determinations of zircons (e.g. Kaye and Zartman, 1980; Krogh *et al.*, 1983). Problems such as the inverse dates of older granites intruding apparently younger volcanics in the Avalon peninsula require further attention (Krogh *et al.*, 1983). A potential key observation is that these igneous rocks are overlain in southeast Newfoundland by about 13 km of sediment that record a cycle of flyschoid to molassic sedimentation that includes both a tillite and Ediacaran fauna (dated at 565 ± 3 myr; Benus, this Bulletin) before the Boundary is reached. Thus, although no radiometric dates for Cambrian rocks, including a series of volcanics (e.g. Greenough *et al.*, 1985; Greenough and Papezik, 1985, 1986), in the Avalon Zone appear to be available, the dating of this magmatic episode at ca. 600 myr and the Ediacaran faunas at ca. 565 myr means that the Boundary may not be much older than 540 myr and could be even younger. If reliable Cambrian dates could be obtained, then this would allow calculation of the average sedimentation rate for this interval and so some assessment of the possible stratigraphic completeness (see Sadler 1981).

The figure for the age of the Boundary in the Avalon Zone is, therefore, broadly in accord with values proposed by Odin and co-workers (see above). Finally, it is worth noting that if the Cambrian Period is agreed to be as short as 40 myr or even 30 myr (i.e. 530-500 myr), then this has considerable implications on our understanding of the rates of metazoan diversification during the so-called "Cambrian explosion." Sepkoski (1981) depicted the increase of familial diversity with the Boundary placed at 575 myr. However, the abruptness and magnitude of this evolutionary event is considerably enhanced if the Boundary is substantially younger than has been generally accepted.

ACKNOWLEDGEMENTS

My thanks to Sandra Last for typing this manuscript. M. A. C. McMenamin, G. S. Nowlan and W. D. Loveridge reviewed the manuscript, and the last referee is offered special thanks for his constructive remarks. Earth Sciences Publication 992.

REFERENCES CITED

Anderson, M.M. 1972. A possible time span for the late Precambrian of the Avalon peninsula, southeastern Newfoundland in the light of worldwide correlation of fossils, tillites, and rock units within the succession. Canadian J. Earth Sci. 9:1710-1726.

Barr, S.M., MacDonald, A.S. and Blenkinsop, J. 1986. The Chéticamp pluton: a Cambrian granodioritic intrusion in the western Cape Breton Highlands, Nova Scotia. Canadian J. Earth Sci. 23:1686-1699.

__________ and Raeside, R.P. 1986. Pre-Carboniferous tectonostratigraphic subdivisions of Cape Breton, Nova Scotia. Maritime Sediments Atlantic Geology 22:252-263.

__________, Sangster, D.F. and Cormier, R.F. 1984. Petrology of Early Cambrian and Devono-Carboniferous intrusions in the Loch Lomond complex, southeastern Cape Breton Island, Nova Scotia. Geol. Surv. Canada Pap. 84-1A:203-211.

Bengtson, S. and Fletcher, T.P. 1983. The oldest sequence of skeletal fossils in the Lower Cambrian of southeastern Newfoundland. Canadian J. Earth Sci. 20:525-536.

Billings, M.P. 1979. Boston Basin, Massachusetts. *In* The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States – Massachusetts, Rhode Island, and Maine. U.S. Geol. Surv. Prof. Pap. 1110A:A15-A20.

Clarke, D.B., Barr, S.M. and Donohoe, H.V. 1980. Granitoid and other plutonic rocks of Nova Scotia. *In* Wones, D.R. (ed.) Proceedings "The Caledonides in the USA." Dept. Geol. Sci., Virginia Polytech. Inst. State Univ. Mem. 2:107-111.

Cloud, P., Wright, J. and Glover, L. 1976. Traces of animal life from 620-million-year-old rocks in North Carolina. Amer. Sci. 64:396-406.

Conway Morris, S. 1987. The search for the Precambrian-Cambrian boundary. Am. Sci. 75:157-167.

Cope, J.C.W. and Gibbons, W. 1987. New evidence for the relative age of the Ercall Granophyre and its bearing on the Precambrian-Cambrian Boundary in southern Britain. Geol. J. 22:53-60.

Cormier, R.F. 1969. Radiometric dating of the Coldbrook Group of southern New Brunswick, Canada. Canadian J. Earth Sci. 6:393-398.

__________ 1972. Radiometric ages of granitic rocks, Cape Breton Island, Nova Scotia. Canadian J. Earth Sci. 9:1074-1086.

Cowie, J.W. and Cribb, S.J. 1978. The Cambrian System. Am. Ass. Petrol. Geol. Stud. Geol. 6:355-362.

__________ and Johnson, M.R.W. 1985. Late Precambrian and Cambrian geological time-scale. *In* The Chronology of the Geological Record. *Edited by* Snelling, N.J. Geol. Soc. Lond. Mem. 10:47-64.

Currie, K.L. 1986. The boundaries of the Avalon tectonostratigraphic zone, Musquash Harbour-Loch Alva region, southern New Brunswick. Geol. Surv. Canada Pap. 861A:333-334.

Dallmeyer, R.D., Odom, A.L., O'Driscoll, C.F. and Hussey, E.M. 1981. Geochronology of the Swift Current granite and host volcanic rocks of the Love Cove Group, southwestern Avalon Zone, Newfoundland: Evidence of a late Proterozoic volcanic-subvolcanic association. Canadian J. Earth Sci. 18:699-707.

Donohoe, H.V., Halliday, A.N. and Keppie, J.D. 1986. Two Rb-Sr whole rock isochrons from plutons in the Cobequid Highlands, Nova Scotia, Canada. Maritime Sediments Atlantic Geology 22:148-154.

Fairbairn, H.W., Bottino, M.L., Pinson, W.H. and Hurley, P.M. 1966. Whole-rock age and initial ^{87}Sr/^{86}Sr of volcanics underlying fossiliferous Lower Cambrian in the Atlantic provinces of Canada. Canadian J. Earth Sci. 3:509-521.

__________, Moorbath, S., Ramo, A.O., Pinson, W.H. and Hurley, P.M. 1967. Rb-Sr age of granitic rocks of southeastern Massachusetts and the age of the Lower Cambrian at Hoppin Hill. Earth Planet. Sci. Lett. 2:321-328.

Frith, R.A. and Poole, W.H. 1972. Late Precambrian rocks of eastern Avalon peninsula, Newfoundland – a volcanic island complex: Discussion. Canadian J. Earth Sci. 9:1058-1059.

Gale, N.H. 1982. Numerical dating of Caledonian times (Cambrian to Silurian). *In* Numerical Dating in Stratigraphy. *Edited by* Odin, G.S. J. Wiley, Chichester, pp. 467-486.

Gaudette, H.E., Olszewski, W.J. and Donohoe, H.V. 1983. Age and origin of the basement rocks, Cobequid Highlands, Nova Scotia. Geol. Soc. Am. Abstr. Prog. 15:136.

Gibson, G.G., Teeter, S.A. and Fedonkin, M.A. 1984. Ediacaran fossils from the Carolina Slate Belt, Stanly County, North Carolina. Geol. 12:387-390.

Greenough, J.D., McCutcheon, S.R. and Papezik, V.S. 1985. Petrology and geochemistry of Cambrian volcanic rocks from the Avalon Zone in New Brunswick. Canadian J. Earth Sci. 22:881-892.

__________ and Papezik, V.S. 1985. Petrology and geochemistry of Cambrian volcanic rocks from the Avalon peninsula, Newfoundland. Canadian J. Earth Sci. 22:1594-1601.

__________ and __________ 1986. Acado-Baltic volcanism in eastern North America and western Europe: Implications for Cambrian tectonism. Maritime Sediments Atlantic Geology 22:240-251.

Harland, W.B., Cox, A.V., Llewellyn, P.G., Pickton, C.A.G., Smith, A.G. and Walters, R. 1982. A geologic time scale. Cambridge University Press, 131 pp.

Hermes, O.D. and Zartman, R.E. 1985. Late Proterozoic and Devonian plutonic terrane within the Avalon Zone of Rhode Island. Bull. Geol. Soc. Am. 96:272-282.

Hughes, C.J. and Brückner, W.D. 1971. Late Precambrian rocks of the eastern Avalon peninsula, Newfoundland – a volcanic island complex. Canadian J. Earth Sci. 8:899-915.

__________ and Malpas, J.G. 1971. Metasomatism in the late Precambrian Bull Arm Formation in southeastern Newfoundland: recognition and implications. Proc. Geol. Ass. Can. 24:8593.

Jamieson, R.A., van Breemen, O., Sullivan, R.W. and Currie, K.L. 1986. The age of igneous and metamorphic events in the western Cape Breton Highlands, Nova Scotia. Canadian J. Earth Sci. 23:1891-1901.

Jenkins, R.J.F. 1984. Ediacaran events: Boundary relationships and correlation of key sections, especially in "Armorica." Geol. Mag. 121:635-643.

Johnson, R.J.E. and Van der Voo, R. 1985. Middle Cambrian paleomagnetism of the Avalon terrane in Cape Breton Island, Nova Scotia. Tectonics 4:629-651.

Kaye, C.A. and Zartman, R.F. 1980. A late Proterozoic Z to Cambrian age for the stratified rocks of the Boston Basin, Massachusetts, U.S.A. *In* Proceedings "The Caledonides in the USA." *Edited* by Wones, D.R. Dept. Geol. Sci., Virginia Polytech. Instit. State Univ. Mem. 2:257-261.

Keppie, J.D. 1982. The Minas geofracture. Spec. Pap. Geol. Ass. Canada 24:263-280.

__________ 1985. The Appalachian collage. *In* The Caledonide Orogen – Scandinavia and Related Areas. *Edited by* Gee, D.G. and Sturt, B.A. J. Wiley, Chichester, pp.1217-1226.

__________ and Halliday, A.N. 1986. Rb-Sr isotopic data from three suites of igneous rocks, Cape Breton Island, Nova Scotia. Maritime Sediments Atlantic Geology 22:162-171.

King, A.F. 1980. The birth of the Caledonides: late Precambrian rocks of the Avalon peninsula, Newfoundland, and their correlatives in the Appalachian-orogen. *In* Proceedings "The Caledonides in the USA". *Edited by* Wones, D.R. Dept. Geol. Sci., Virginia Polytech. Inst. State Univ. Mem. 2:3-8.

__________ (ed.). 1982. Field Guide for Avalon and Meguma Zones. The Caledonide Orogen IGCP Project 27, NATO Advanced Study Institute, Atlantic Canada, August 1982. Memorial University, St. Johns, Newfoundland, 308 p.

King, L.H., Fader, G.B.J., Poole, G.B.J. and Wanless, R.K. 1985. Geological setting and age of the Flemish Cap granodiorite, east of the Grand Banks of Newfoundland. Canadian J. Earth Sci. 22:1286-1298,

Kovach, A., Hurley, P.M. and Fairbairn, H.W. 1977. Rb-Sr whole rock age determinations of the Dedham granodiorite, eastern Massachusetts. Am. J. Sci. 277:905-12.

Krogh, T.E., Strong, D.F. and Papezik, V. 1983. Precise U-Pb ages of zircons from volcanic and plutonic units in the Avalon Peninsula. Geol. Soc. Am. Abstr. Prog. 15:135.

La Forge, L. 1932. Geology of the Boston area, Massachusetts. U.S. Geol. Surv. Bull. 839, 105 p.

Leech, G.B., Lowdon, J.A., Stockwell, C.H. and Wanless, R.K. 1963. Age determinations and geological studies (including isotopic ages – Report 4). Geol. Surv. Canada Pap. 63-17:1140.

Lowdon, J.A., Stockwell, C.H., Tipper, H.W. and Wanless, R.K. 1963. Age determinations and geological studies (including isotopic ages – Report 3). Geol. Surv. Canada Pap. Can. 6217:1-140.

McCartney, W.D., Poole, W.H., Wanless, R.K., Williams, H. and Loveridge, W.D. 1966. Rb/Sr age and geological setting of the Holyrood Granite, southeastern Newfoundland. Canadian J. Earth Sci. 3:947-957.

O'Brien, S.J., Wardle, R.J. and King, A.F. 1983. The Avalon Zone: a pan-African terrane in the Appalachian orogen of Canada. Geol. J. 18:195-222.

Odin, G.S., Gale, N.H., Auvray, B., Bielski, M., Dore, F., Lancelot, J.-R. and Pasteels, P. 1983. Numerical dating of Precambrian-Cambrian boundary. Nature 301:21-23.

__________, and Doré, F. 1985. Radiometric dating of late Precambrian times. *In* The Chronology of the Geological Record. *Edited by* Snelling, N.J. Geol. Soc. Lond. Mem. 10:65-72.

O'Driscoll, C.F. and Gibbons, R.V. (eds.) 1980. Geochronology report – Newfoundland and Labrador. Current Research, Min. Dev. Div., Dept. Mines Energy, St. John's, Rep. 80-1:143146.

Olszewski, W.J. and Gaudette, H.E. 1982. Age of the Brookville Gneiss and associated rocks, southeastern New Brunswick. Can. J. Earth Sci. 19:2158-2166.

Patchett, P.J., Gale, N.H., Goodwin, R. and Humm, M.J. 1980. Rb-Sr whole-rock isochron ages of late Precambrian to Cambrian igneous rocks from southern Britain. J. Geol. Soc. Lond. 137:649-656.

Pelletier, B.R. 1971. A granodiorite drill-core from the Flemish Cap, eastern Canadian continental margin. Canadian J. Earth Sci. 8:1499-1503.

Piqué, A. 1981. Northwestern Africa and the Avalonian plate: Relations during late Precambrian and late Paleozoic time. Geol. 9:319-322.

Poole, W.H. 1980a. Rb-Sr age of Shunacadie pluton, central Cape Breton Island, Nova Scotia. Geol. Surv. Canada Pap. 801C:165-169.

__________ 1980b. Rb-Sr age of some granitic rocks between Ludgate Lake and Negro Harbour, southwestern New Brunswick. Geol. Surv. Canada Pap. 80-1C:170-173.

Rast, N. 1980. The Avalonian plate in the northern Appalachians and Caledonides. *In* Proceedings "The Caledonides in the USA." *Edited by* Wones, D.R. Dept. Geol. Sci., Virginia Polytech. Inst. State Univ. Mem. 2:63-66.

__________, O'Brien, B.H. and Wardle, R.J. 1976. Relationships between Precambrian and lower Palaeozoic rocks of the "Avalon platform" in New Brunswick, the northeast Appalachians and the British Isles. Tectonophys. 30:315338.

__________ and Skehan, J.W. 1983. The evolution of the Avalonian plate. Tectonophy. 100:257-286.

Sadler, P.M. 1981. Sediment accumulation rates and the completeness of stratigraphic sections. J. Geol. 89:569584.

Secor, D.T., Samson, S.L., Snoke, A.W. and Palmer, A.R. 1983. Confirmation of the Carolina slate belt as an exotic terrane. Sci. 221:649-651.

Seguin, M.K. 1985. Paleomagnetism of the Avalonian Finn Hill sequence of eastern Newfoundland, Canada. Maritime Sediments Atlantic Geol. 21:55-68.

Sepkoski, J.J. 1981. A kinetic model of Phanerozoic taxonomic diversity II. Early Phanerozoic families and multiple equilibria. Paleobio. 5:222-251.

Skehan, J.W. and Murray, D.P. 1980. A model for the evolution of the eastern margin (EM) of the northern Appalachians. *In* Proceedings "The Caledonides in the USA." *Edited by* Wones, D.R. Dept. Geol. Sci., Virginia Polytech. Inst. State Univ. Mem. 2:67-72.

Smith, B.M. and Giletti, B.J. 1978. Rb-Sr whole rock study of the deformed porpyritic granitic rocks of Aquideck and Conanicut Islands, Rhode Island. Geol. Soc. Am. Abstr. Prog. 10:86.

Strong, D.F. 1979. Proterozoic tectonics of northwestern Gondwanaland: new evidence from eastern Newfoundland. Tectonophys. 54:81-101.

__________ and Minatedis, D.G. 1975. Geochemistry and tectonic setting of the late Precambrian Holyrood plutonic series of eastern Newfoundland. Lithos 8:283-295.

Wanless, R.K., Stevens, R.D., Lachance, G.R. and Delabio, R.N. 1974. Age determinations and geological studies. K-Ar isotopic ages, Report 11. Geol. Surv. Canada Pap. 73-2:1139.

Webster, M.J., Skehan, J.W. and Landing, E. 1986. Newly discovered Lower Cambrian rocks of the Newport Basin, southeastern Rhode Island. Geol. Soc. Am. Abstr. Prog. 18:75.

Weeks, L.J. 1954. Southeast Cape Breton Island, Nova Scotia. Geol. Surv. Can. Mem. 277, 112 p.

Williams, H. and Hatcher, R.D. 1983. Appalachian suspect terranes. Geol. Soc. Am. Mem. 158:33-53.

Wright, J.E. and Seiders, V.M. 1980. Age of zircon from volcanic rocks of the central North Carolina Piedmont and tectonic implications for the Carolina volcanic slate belt. Bull. Geol. Soc. Am. 91:287-294.

Zartman, R.E. and Naylor, R.S. 1984. Structural implications of some radiometric ages of igneous rocks in southeastern New England. Bull. Geol. Soc. Am. 95:522-539.

Stratigraphy of the Bonavista Group, Southeastern Newfoundland: Growth Faults and the Distribution of the Sub-trilobitic Lower Cambrian

Ed Landing[1] and Alison P. Benus[2]

[1] New York State Geological Survey, The State Education Department
[2] Department of Earth Sciences, Memorial University of Newfoundland

ABSTRACT

The upper part of the sub-trilobitic Lower Cambrian of southeastern Newfoundland, traditionally referred to the Bonavista Formation and the Smith Point Limestone, overlies the Random Formation and older units with regional angular unconformity. This sequence is itself unconformably overlain by the trilobite-bearing Lower Cambrian. This unconformity-bounded interval is referred to the Bonavista Group (revised).

Progressive onlap of the Bonavista Group took place during extension of a terrane that had undergone post-Random and pre-Bonavista block faulting and erosion. The lowest units of the Bonavista Group, the Petley Formation (new) and West Centre Cove Formation (new), are limited to the Placentia Bay – Bonavista Bay "axis" where they overlie the Random and older (Chapel Island, Musgravetown) units. This suggests several hundred meters of differential movement on post-Random block faults. The Placentia-Bonavista "axis" received the thickest accumulation of the younger Cuslett Formation (new), a unit that represents most of the Bonavista Group and which onlapped east into the western Conception Bay and St. Mary's Bay regions. Regional shoaling near the end of deposition of the Bonavista Group is marked by widespread deposition of the thin Fosters Point Formation (new, = lower part of the "Smith Point Limestone").

Trilobites appear in southeastern Newfoundland above a readily recognizable unconformity within the "Smith Point Limestone." These limestones are referred to the base of the Brigus Formation (emended) and mark a diachronous onlap of the trilobite-bearing Lower Cambrian. The abrupt faunal turnover across the unconformity between the Fosters Point Formation and overlying Brigus Formation includes the disappearance of many small shelly fossils of the Bonavista Group and the physically abrupt first-appearance of trilobites, mollusks, and small shellys. Nondeposition/erosion of the highest sub-trilobitic strata and nondeposition of the lowest trilobite-bearing sediments, and not catastrophic events or linked litho- and biofacies shifts, seem to be appropriate in explanation of this faunal turnover.

A uniform stratigraphic nomenclature can be applied to the Cambrian of southeastern Newfoundland. The "Inlet Group" in the Burin Peninsula and western Placentia Bay region includes the "Bay View Formation" (= Chapel Island Formation), "Salt Pond Formation" (= Petley through Fosters Point Formations of the Bonavista Group and Brigus Formation), and "Pleasant View Formation" (= Chamberlains Brook and Manuels River Formation). The stratigraphic units of the western Burin Peninsula and Avalon Peninsula are readily recognizable in the Burin Peninsula.

INTRODUCTION

Previous investigations

Lower Cambrian stratigraphy of southeastern Newfoundland was first documented in the classic Trinity Bay and Conception Bay regions (see Hutchinson (1962), Jenness (1963) and Fletcher (1972) for reviews of nomenclature). In the Trinity Bay area (Figure 34), the upper Precambrian is overlain by distinctive, white to grey, reddish, and green siliceous quartz arenites (locally massive) and associated brown and green siltstones of the Random Formation (Walcott, 1900; emended by Christie, 1950). The Lower Cambrian sequence above the Random reflects a significant change in depositional regimes from the frequently high-energy tidal environments of the Random Formation (Hiscott, 1982) to one associated with deposition of siliciclastic mudstones and minor nodular and bedded carbonates. These fossiliferous mudstones and limestones are red, purple, green and grey in color through the lower Middle Cambrian (= Adeyton Group of Jenness, 1963) while the higher Middle Cambrian to Lower Ordovician is dark grey and brown to black (= Harcourt Group of Jenness, 1963).

Hutchinson's (1962) stratigraphic synthesis of the Adeyton Group was particularly important because it standardized the formational nomenclature, proposed type sections for earlier named formations, and emphasized that a uniform stratigraphic scheme could be applied in the Bonavista, Avalon, and Burin Peninsulas. Hutchinson's (1962) Lower Cambrian was considered to be a conformable succession that included three formations (from top to bottom):

> Brigus Formation (van Ingen, 1914; red to green siliciclastic mudstones and limestones with trilobite-dominated fauna, overlain by often manganiferous, mudstones and limestones of the lower Middle Cambrian Chamberlains Brook Formation)
>
> Smith Point Limestone (Walcott, 1900; relatively thin, persistent red limestone-dominated unit, lowest trilobites appearing at top of unit)
>
> Bonavista Formation (van Ingen, 1914; red, purple, green and locally grey siliciclastic mudstones and minor limestones with sub-trilobitic fauna including hyoliths, *Coleoloides*, mollusks and other forms).

As a number of subsequent authors (e.g. Jenness, 1963; Fletcher, 1972), Hutchinson (1962) referred the underlying Random Formation to the Precambrian because of the abrupt change in environments across an apparently unconformable Random-Bonavista contact and the seeming absence of Cambrian-aspect fossils in the Random. Although this unconformity is no longer regarded as a systemic boundary because Cambrian-aspect small shelly fossils and trace fossils occur below the Random in the Chapel Island Formation in the southwestern Burin Peninsula (Greene and Williams, 1974; Bengtson and Fletcher, 1983; Crimes and Anderson, 1985; Narbonne *et al.*, 1987), this contact marks an important stage in the geologic evolution of southeastern Newfoundland (discussed below).

Present study

Our interest in the post-Random Lower Cambrian was originally prompted by several interesting features of the

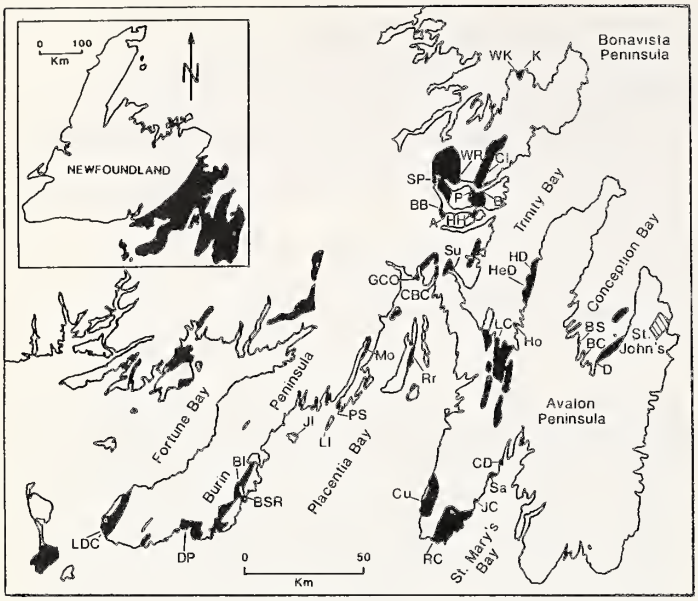


Figure 34. Measured sections in the Bonavista Group (see Figures 35, 36 and localities mentioned in text. Black areas on map are Cambrian-Ordovician outliers. Locality abbreviations: A, Adeyton, section 200 m east of beach at north side of village; B, east end of cove forming harbor at Village of Britannia; BB, Bottom Bluff, shore section 0.5 km northeast of wharf at Village of Deep Bight; BC, Bacon Cove, section extends from 250 m south of government wharf to hill crest to north; BI, Burin Inlet, section east of Lunes Cove at head of Burin Inlet; BS, Brigus South Point, from deep cove at south end of point; BSR, Big Salmonier River, shore section 1.5 km south of mouth of river; CBC, Come-By-Chance, shore cliffs 0.5-1.0 km south of government wharf; CCo, shore section at Chapels Cove; C1, Clifton, shore section 1.0 km west of Clifton and continuing along road cuts into the village; Cu, Cuslett, cove located mid-way between Village of Cuslett to northeast and Perch Cove to south; D, Duffs, shore section south of Holyrood Generating Station; DP, Duck Point; GCo, Goose Cove, south of Village of North Harbour on tip of peninsula at old hamlet of Goose Cove (abandoned); HD, Heart's Desire, south side of harbor; HeD, Heart's Delight, south side of harbor; HH, Hickmans Harbour, section along shore ca. 1.5 km southeast of harbor; Ho, section on southwest end of Hopeall Head; JC, Jigging Cove, shore section on north side of outlet of Red Head River; JI, Jude Island, section on northeast side of island; K, Keels, east limb of syncline; LC, Long Cove, section on point at north end of Village of Long Cove; LDC', section at north side of Little Dantzic Cove; LI, Long Island, section on southwest side of island; Mo, Monkstown, section at north end of harbor where road descends to water level from north; Mr, stream section below Rte. 60 bridge on Manuels River; P, Petley, shore section located 0.35 km northwest of government wharf; PS, Paradise Sound, section on south end of Red Cove Head; RC, Redland Cove, section on west side and tip of Redland Point; Rr, long section in sea cliffs beginning 2.0 km north of old whaling station at Rose-au-rue and extending south to the north side of cove at Rose-au-rue (Merasheen Island); Sa, Little Salmonier Point; SP, Smith Point, section extending along shore southeast and south of Village of Harcourt; Su, Sunnyside, shore section along Bull Arm and Centre Cove and extending north over hill crest; TS, beach section north of Topsail; WK, West Keels, section through west limb of syncline; WR, White Rock, Random-Bonavista Group contact at hamlet of White Rock (abandoned).

Bonavista and Smith Point. These include the abrupt appearance of the lowest trilobites of the region in the top of the Smith Point (Fletcher, 1972), the localization of maximum accumulation of the Bonavista along a narrow, elongate axis running through Placentia Bay and trending north-northeast through western Trinity Bay and the central Bonavista Peninsula (= Placentia-Bonavista "axis," below), and the potential use of nodular and bedded limestones and mudstone color alternations noted by Hutchinson (1962) in the Bonavista for regional correlations. This study over the last six years has also involved bed-by-bed examination of small shelly fossils and microfacies of the sub-trilobitic and trilobite-bearing Lower Cambrian that will be referred to here but documented elsewhere. The locations of stratigraphic sections and information on thickness and marker beds are summarized in Figures 34-36. Except where otherwise indicated, this summary is based on our field and laboratory work.

MAJOR STRATIGRAPHIC BREAKS

Sub-Bonavista unconformity

Random-Bonavista unconformity.—Hutchinson (1962; see Jenness, 1963; Fletcher, 1972) discussed the evidence for unconformity at a number of localities that expose the Random-Bonavista contact. We have examined these localities and have found physical evidence for unconformity at almost all Random-Bonavista contacts. Unconformable relationships are typically indicated by a bed of relatively unique composition that separates the quartzite or thin bedded sandstones at the top of the Random from the overlying finer-grained Bonavista sediments. At a number of localities, this initial bed of Bonavista overlies a surface showing erosional relief on the Random: Cuslett (locality Cu, broad channel-like cut-out, 1.3 m-deep, on quartzite; Hutchinson, 1962; this report), Sunnyside (Su, 35 cm of relief; Stop 6, Field Trip, this Bulletin), White Rock (WR, 10 cm of relief), Long Cove (LC, 20 cm of relief, Stop 6, Field Trip, this Bulletin), Heart's Delight (locality HeD, 27 cm of relief).

Three intergradational types of deposits overlie the Random Formation in the Bonavista and Avalon Peninsulas: Type A, calcareous quartz arenite bed with quartz sandstone and vein quartz pebbles and other pebbles (frequently argillite) derived from the upper Precambrian as well as fragments of early diagenetic calcareous nodules reworked from the initial onlap deposits of the Bonavista; Type B, interbedded siliciclastic mudstones and finer grained quartz arenites; and Type C, stromatolitic or algal mud mound limestone, typically red, with hyolith and conoidal fossil wacke- to grainstone lenses. Contacts dominated by Type A and Type B facies at the base of the Bonavista are most common. A list of these types of contacts from northern to more southern localities, with thicknesses of the reworked sediment interval, includes the following: Keels (locality K, 0.15 m, Type A), West Keels (WK, 0.3 m, Type A; Jenness, 1963, and this report), White Rock (WR, 0.5-0.6 m,

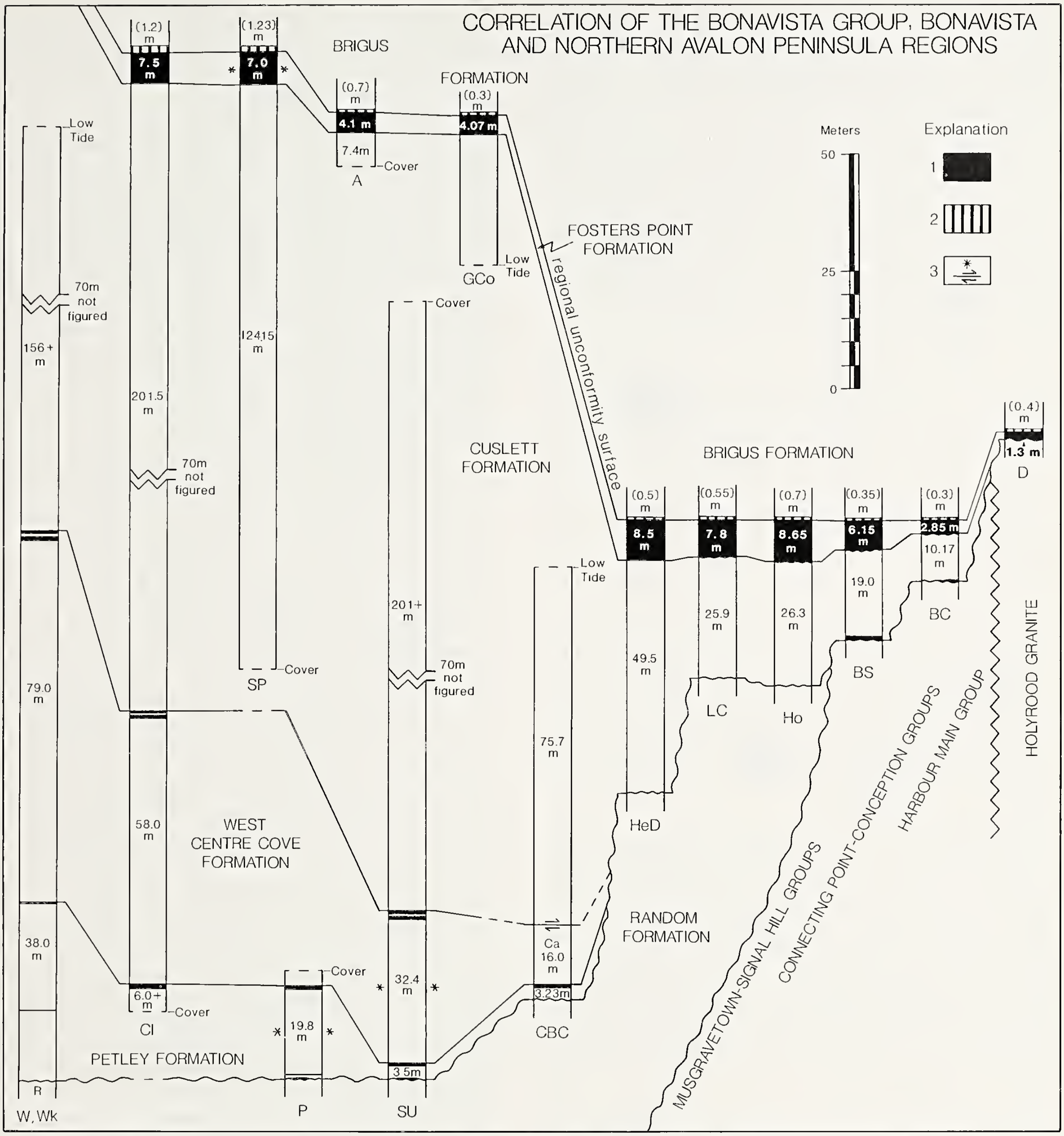


Figure 35. Correlations of the Bonavista Group in the Bonavista and northern Avalon Peninsula regions. Local thickness of each formation of the Group noted within columns. Explanation: 1, bedded limestones (sub-trilobitic), commonly with algal mud mounds, large hyoliths, oncolites, and stromatolites; 2, trilobite-bearing limestone at base of Brigus Formation (emended), this limestone had been assigned to the top of the "Smith Point Limestone" in all previous reports, thickness given in parentheses; 3, asterisk (*) indicates type sections of the Petley, West Centre Cove, Cuslett, and Fosters Point formations of the Bonavista Group, lower symbol indicates fault with significant stratigraphic cut-out. Thickness of Random Formation and older units not to scale. See Figure 34 for localities (= abbreviations at base of columns); undulatory lines indicate postRandom unconformity surface, local unconformity at base of Fosters Point in western Conception Bay and eastern Trinity Bay localities indicated, regional unconformity at base of Brigus Formation discussed in text.

Type B; Jenness, 1963, and this report), Petley (P, 1.06 m, Type B), Hickman Harbour (HH, 0.6 m, Type A; Jenness, 1963, and this report); Sunnyside (Su, 1.16 m, Type B; Stop 6, Field Trip, this Bulletin), Heart's Delight (HeD, 0.27 m, Type A with phosphate pebbles), Hopeall Head (Ho, 0.35 m, Type A; Hutchinson, 1962, and this report), Long Cove (LC, 0.2 m, Type A; Stop 10, Field Trip, this Bulletin), and Little Salmonier Point (Sa, 0.3 m, Type A; Hutchinson, 1962, and this report). Type C contacts, with limestone overlying the Random, are best developed at two localities: Cuslett (Cu, 0.6 m-thick limestone laterally transitional into calcareous quartzites) and Bottom Bluff (BB, 0.3 m of limonitized planar and SH-V ("*Collenia*"-type) stromatolites). Limestones which were largely eroded away by the higher energy environments during initial onlap also occur at Petley (P) and Sunnyside (Su) (see Figure 35).

Diachroneity of post-Random onlap and regional angular unconformity.—Available evidence has long been suggestive of a time transgressive onlap of the post-Random Lower Cambrian. Localities east and west of the Placentia-Bonavista "axis" have units younger than the Bonavista in unconformable contact with the underlying Random Formation. These include Jigging Cove and Little Dantzic Cove Brook (localities JC and LDC'; see Hutchinson, 1962, and Stop 5, Field Trip, this Bulletin) where the "Smith Point Limestone" and Brigus Formation, respectively overlie the Random. In addition, easterly Lower Cambrian onlap brings the Bonavista and Brigus down onto the upper Precambrian in Conception Bay (localities BC, BS and D; see McCartney, 1969). Although a number of reports have proposed that the Random Formation is a time-transgressive, shoreline deposit (McCartney, 1969; Greene and Williams, 1974), the presence of reworked Random sand and erosional relief at the first two localities (see Stop 5, Field Trip, this Bulletin) and absence of the Random in Conception Bay suggest that the Random is not part of the cumulative onlap of the higher Lower Cambrian.

Fletcher (1972) was the first to suggest a regional angular unconformity at the base of the post-Random Lower Cambrian. This was based on sections on the large peninsula between southeastern Placentia and southwestern St. Mary's Bays. In this area, the Bonavista can be demonstrated to overlie successively lower horizons in the Random toward Cape St. Mary's and the axis of the peninsula (Fletcher, 1972). The consequence of this progressive cut-out is well illustrated at Redland Cove (locality RC, see Figures 34, 36) where a relatively thin section of Bonavista overlies the Musgravetown Group with no intervening Random.

Redland Cove and adjacent areas also illustrate that Bonavista onlap was diachronous. In the Bonavista Peninsula, west Trinity Bay, and eastern Placentia Bay area, we have been able to make correlations within the lower part of the Bonavista "Formation" by using two regionally extensive limestone units (see Figures 35, 36). These limestone units are relatively thick bedded (0.25-1.5 m thick) and are characterized by algal mud mounds, by faunas dominated by large hyoliths, and, frequently, by dessication-cracked algalaminates near their top. These limestones differ strongly from the fine-grained nodular carbonates in the lower part of the Bonavista and also contrast strongly with the thin, pink small shell-wackestones in the upper part of the Bonavista. They resemble the limestones laid down on the shoreline during onlap and are interpreted as the result of offlap and shoaling during deposition of the lower Bonavista (see Figure 37, and Stops 6, 8, 9A, Field Trip, this Bulletin).

Although these two peritidal limestones are present at Cuslett (locality Cu), only the upper second limestone occurs at Redland Cove (locality RC, see Figure 37). The Redland Cove section of the Bonavista is thinner than that at Cuslett by loss of the lower part of the Bonavista and probably, by condensation of the upper part of the "formation." The massive sub-trilobitic limestone (= lower "Smith Point") maintains a constant thickness between the two localities and crosses the peninsula to appear in St. Mary's Bay (see locality JC, Figure 37). The lack of appreciable amounts of siliciclastic sand at these localities suggests that a lower rate of subsidence of the Cape St. Mary's region, rather than the presence of a relatively high-standing mainland during Bonavista onlap, may explain the diachroneity of the transgression.

A comparable intra-Lower Cambrian angular unconformity is apparently present in western Placentia Bay and the eastern and southern parts of the Burin Peninsula. In this region, the same two limestone units that have been traced for 205 km along depositional strike from Keels (locality K) to Redland Cove are useful in precise correlations of the lower part of the Bonavista. Correlations across the Placentia-Bonavista "axis" in this area are interesting because the Random is absent at most localities in this huge region. For example, the Bonavista rests on nodule-bearing purple and green siliciclastic mudstones referable to upper member 3 or member 4 of the Chapel Island Formation at Monkstown (Mo, see Figure 36). The first and second limestones of the Bonavista have undergone a facies change, respectively, into a purplish-pink algal mound limestone and a brick-red, stromatolitic, oncolitic and *Aldanella*-rich unit at Monkstown. However, the lower limestone has undergone this change in lithology at Come-By-Chance (locality CBC) and there is little reason to suggest that these two limestones are not identical to the two limestones on the east side of the Placentia-Bonavista "axis." These limestones are recognizable for 140 km to the southwest of Monkstown and occur in sections where the Bonavista overlies the Chapel Island Formation at Burin Inlet (locality BI; see Figure 7, Lewins Cove) and Duck Point (locality DP). At Duck Point, the first limestone directly overlies the unconformity with the Chapel Island Formation (Figure 36). The east-west transect from Merasheen Island (locality Rr) to Monkstown (Mo) is similar to that discussed above for Cuslett and Redland Cove; the Bonavista thins significantly away from the Placentia-Bonavista "axis" in both cases.

The Random Formation is also absent on a number of islands in western Placentia Bay, and the Chapel Island Formation is directly overlain by the first limestone with the second limestone of the Bonavista a few meters higher in the section (e.g. Jude Island and Long Island, localities JI and LI; see O'Brien and Taylor, 1983). Outcrops of Random Formation with overlying Bonavista occur on Red Head at Paradise Sound (locality PS; O'Brien and Taylor, 1983) where the Random is only a little over a meter in thickness. This particular locality seems to lie at the western feather edge of the Random in Placentia Bay.

In summary, the Random Formation has a discontinuous dis-

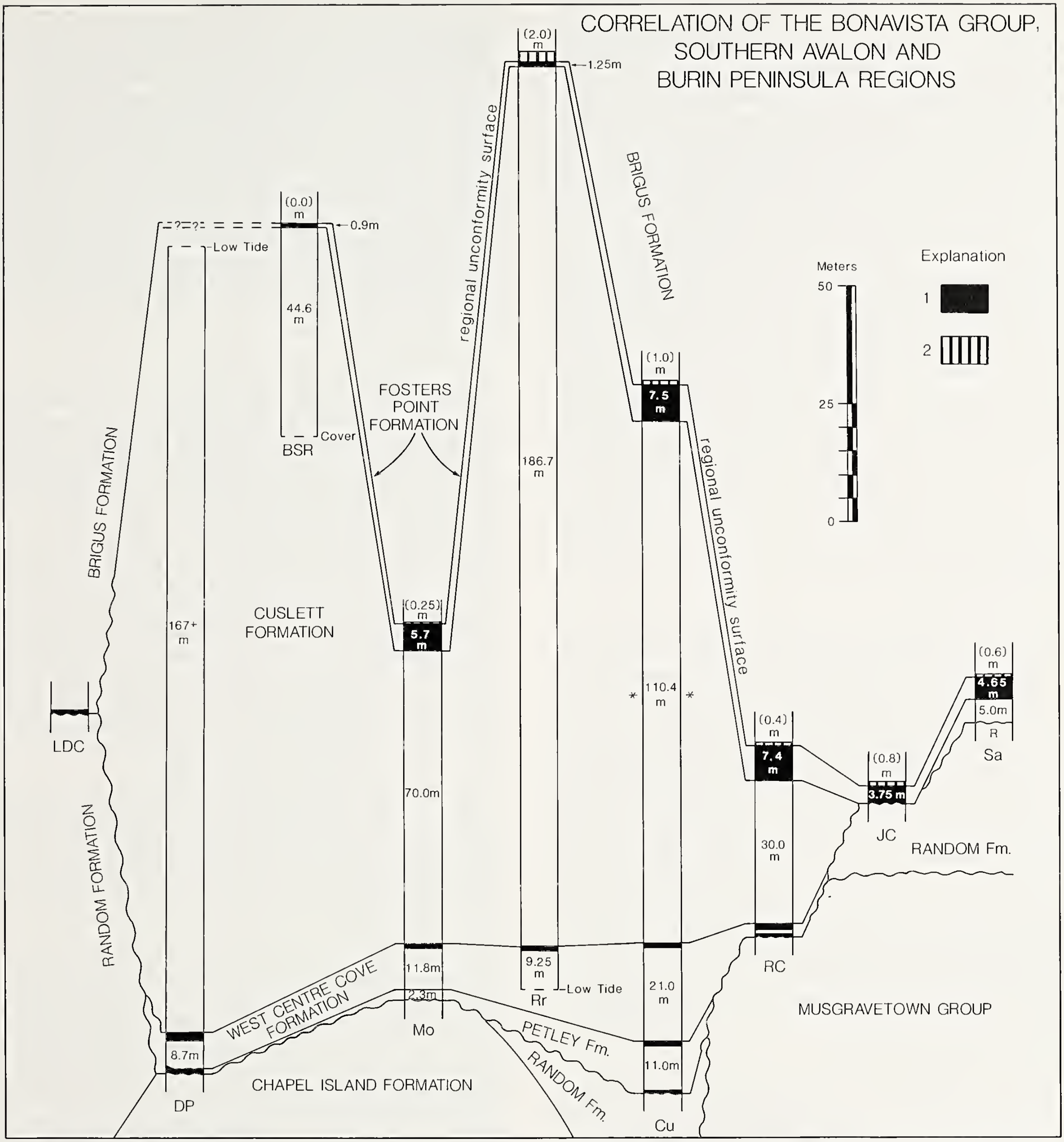


Figure 36. Correlations of the Bonavista Group in the southern Avalon and Burin Peninsula regions. See Figure 34 for localities and Figure 35 for Explanation.

tribution in parts of southeastern Newfoundland. It is a thick unit (ca. 250 m) at the southwestern end of the Burin Peninsula (Stop 4G, Field Trip, this Bulletin). However, the Random disappears in the south-central and eastern parts of the Burin Peninsula where the Bonavista rests directly on the Chapel Island Formation. The Random reappears as a meter-thick unit at Paradise Sound (locality PS) and is about 45 m-thick across Placentia Bay at Cuslett (Fletcher, 1972). It again disappears across Cape St. Mary's but reappears again in St. Mary's Bay (locality JC). If the Random was a regionally extensive unit, then several hundred meters of uplift, considerably more than that which took place in the Cape St. Mary's region (ca. 80 m; Fletcher, 1972, Fig. 8) would be required to allow erosion of the Random and upper Chapel Island Formation and allow deposition of the Bonavista on the middle part of the Chapel Island at Duck Point (Figures 6, 36).

Easterly Bonavista onlap.—The Bonavista rapidly thins from the "thick" sequences in the western Trinity Bay region (localities K, C1, Su) into the "thin" sections of southern and eastern Trinity Bay (localities LC, Ho, HD, HeD). Fletcher (1972) considered that the "thin" sections were either condensed or basally incomplete equivalents of the "thick" sections. Although lack of outcrop along the Isthmus of Avalon does not allow complete documentation of the thickness and facies changes between the "thin" and "thick" sequences, the second alternative is apparently the most appropriate solution to this problem in correlation within the Bonavista.

This conclusion is based on the appearance of a 1.0-2.5 m-thick interval of algal mud mound limestone in the upper part of the siliciclastic mudstones at the southern and eastern Trinity Bay localities (see Figure 34, locality LC, 22.3-23.55 m-interval; Stop 10, Field Trip, this Bulletin). Comparable limestones are found in the "thick" sequences only in the upper part of the Bonavista (= "member 2" and "member 3" of the Cuslett Formation; see Stops 6, 8, Field Trip, this Bulletin). The stratigraphic position of these limestones a short distance below the thick limestone at the top of the sub-trilobitic Lower Cambrian (= lower "Smith Point Limestone") suggests that they are correlative with "member 3" in western Trinity Bay. This correlation suggests that the hiatus between the Random and Bonavista is substantially longer in eastern than in western Trinity Bay.

Regional extension and Lower Cambrian onlap.—The easterly onlap of the Bonavista and higher Lower Cambrian units seems to have been accompanied by regional extension. Evidence for extension is presently known in western Trinity and eastern Placentia Bays and southern Conception Bay.

Initial sediments low in the Bonavista Group (= base of Petley Formation, see below) fill sharply-defined, noneroded fissures in the Random Formation at several localities. These joint fissures reach 10-cm depths at Sunnyside in western Trinity Bay (Su, Stop 6, Field Trip, this Bulletin) and at Cuslett in eastern Placentia Bay. Interestingly, extension seems to have accompanied subsequent deposition of the Bonavista in this region. This is suggested by fissure-fills in the 0.5 m-thick limestone located ca. four meters above the base of the Bonavista at Sunnyside (= top of Petley Formation, Stop 6, Figure 30). These fractures are 1-2 cm-wide and run completely through this red limestone at Sunnyside; the fractures are filled with green shale derived from the overlying West Centre Cove Formation.

Spectacular examples of joints filled with Lower Cambrian sediments occur in the Conception Bay region. King and Anderson (1982, p. 59) reported "vein-like fissures" in the Conception Group that are filled with Lower Cambrian sand and carbonate at Bacon Cove (locality BC) in western Conception Bay. We have measured 60 cm-deep deep fissures at this locality that reflect E-W directed tension at this locality. Even deeper (2.25 + m) fissures occur at Chapel's Cove (locality CCO) where a very thin shale-dominated sequence (3.5 m) of the upper part of the Bonavista directly overlies granites of the Holyrood pluton. These shales have disappeared just to the east of Chapels Cove at Duffs (locality D) where phosphatized sediments of the overlying "Smith Point Limestone" (= Fosters Point Formation) overlie granophyre of the Holyrood pluton (Figure 35). Sediment-filled fissures at Duffs (see Anderson, 1987) reach a depth of 0.9 + m.

The presence of "fresh-appearing" (i.e. sharp, erosion unmodified) fissures in the terrane under the easterly-onlapping sediments of the Bonavista Group (inclusive of the lower "Smith Point Limestone" or Fosters Point Formation, see below) and the local occurrence of fissure-fills in limestones within the Bonavista Group suggest that regional extension accompanied post-Random onlap. This gentle extension appears to have been a relatively long-term phenomenon in southeastern Newfoundland because older (Petley Formation) through younger (Fosters Point Formation) units of the Bonavista Group fill the fissures.

Intra-"Smith Point" unconformity

Localities.—Trilobites make an abrupt lowest appearance in southeastern Newfoundland in the uppermost part of the "Smith Point Limestone" at most localities. The sole exception is Big Salmonier River (locality BSR) where trilobites appear in immediately overlying red shales and interbedded thin (3-5 cm) limestones of the Brigus Formation.

Trilobite fragments may be somewhat difficult to see in the tightly-lithified, often slaty wacke- to packstone cap of the "Smith Point." This may explain Fletcher's (1972) restriction of trilobites to the uppermost 27 cm of the "Smith Point" at all localities even though Hutchinson (1962) had reported them as low as 60 cm below the top. Field observations, particularly on weathered surfaces, and slabbed sections demonstrate that trilobites occur as low as 2.0 m below the top of the "Smith Point" at some localities (Rose-au-rue, locality Rr). At most sections (Figures 35, 36), trilobites are present less than 0.5 m below the massive cap of the "Smith Point."

Little discussion has been given to the seemingly abrupt appearance of the lowest trilobites in southeastern Newfoundland. Fletcher (1972, p. 168) regarded their appearance as an "instantaneous influx." However, available evidence suggests that trilobites accompany onlap across an important, regional unconformity surface.

Physical evidence of unconformity.—Erosional relief and truncation, a coarse-grained siliciclastic layer, and abrupt facies changes accompany the appearance of trilobite-bearing limestone at the top of the "Smith Point." Local erosional cutout of 15 cm to 20 cm of the top of the sub-trilobitic part of the "Smith Point" is present at Smith Point and Cuslett (localities SP, Cu) and this irregular surface is overlain by trilobite wacke- and packstones. Similarly, limonite-impregnated oncolites are truncated immediately below the lowest trilobite-bearing horizon at Jigging Cove and Little Salmonier Point (localities JC, Sa). Pebbles of vein quartz and upper Precambrian argillite and large grains of feldspar at Goose Cove (locality GCo) and a cross-bedded, quartz arenite bed at Long Cove (locality LC, see Stop 6, Field Trip, this Bulletin) are unknown elsewhere in this part of the sequence, and their occurrence suggests re-working of land-derived clastics with the initial deposition of trilobite-bearing limestone. Finally, an abrupt change from algal mud mound limestones to oncolitic trilobite wacke- to packstones is present at a number of localities (A, BC, C1, Cu, Ho, Sa, Sp). While this indicates distinctive environments in the sub-trilobitic and trilobite-bearing Lower Cambrian, it should be regarded as a possible consequence of but not evidence for a significant break in deposition. However, a two cm-thick limonitic, dessication-cracked algalaminate occurs between algal mud mounds and the lowest trilobite-bearing limestones on Merasheen Island (locality Rr) and is evidence for subaerial exposure. A similar limonite-impregnated algalaminate occurs between reddish-grey, abundantly fossiliferous, mollusk-dominated sub-trilobitic wacke- and packstones and an overlying grey-green limestone bed (0.4 m-thick) at Chapels Cove (CCo) and Duffs (D) in southern Conception Bay. This algalaminate is also impregnated by phosphate at the latter localities and mantles a surface that shows approximately 5 cm of erosional relief on the sub-trilobitic limestones.

Diachronous unconformity.—The deposition of the upper part of the "Smith Point" seems to have taken place during a diachronous onlap of the trilobite-bearing Lower Cambrian over the eroded top of the sub-trilobitic "Smith Point." Fletcher (1972) recorded a low diversity, lower *Callavia* Zone fauna ("*Acanthomicmacca* Subzone") from the top of the "Smith Point" at the southernmost section in southeastern Newfoundland (locality RC). This low diversity fauna persists through the overlying 17.5 m of the Brigus Formation at locality RC where it is replaced by the higher "*Dipharus* Subzone" fauna. It is significant that trilobites that are not lower than Fletcher's (1972) "*Dipharus* Subzone" are reported from the top of the "Smith Point" at more northerly localities (e.g., locality SP; see Hutchinson, 1962) where all known trilobite faunas are younger than those from the cap of the "Smith Point" at Redland Cove (T.P. Fletcher, pers. commun., 1986).

Duration of unconformity.—The regional unconformity between the sub-trilobitic and trilobite-bearing parts of the "Smith Point" marks an abrupt change-over in faunas. Many species (approximately 60%) of the stratigraphically long-ranging, small shelly faunas of the sub-trilobitic Lower Cambrian disappear at the unconformity (including *Rhombocorniculum insolutum*, *Aldanella attleborensis*, *Watsonella crosbyi*, *Pojetaia? terranovica*, "*Ginella*" *acutacosta* and, apparently, *Tiksitheca korobovi* (= *Anabarites trisulcatus*), among others). At least three genera of trilobites, *Linguella*, *Obolella*, a large naticiform snail (undescribed), and *Microdictyon* appear above the unconformity (EL, unpub. data).

We caution fanciers of the massive body impact school of faunal extinction/replacement that two legitimate explanations are available for the abrupt replacement of faunas in the upper part of the "Smith Point." These include an abrupt litho- and biofacies shift, possibly driven by onlap (see Ludvigsen and Westrop, 1983), or loss of the upper and lower ranges, respectively, of the sub-trilobitic and trilobite-bearing faunas by erosion and non-deposition during the hiatus. The first explanation is considered unlikely because the mixed siliciclastic-carbonate facies below and above the unconformity are comparable and suggest similar environments. A relatively long-term hiatus followed by onlap and the local appearance of new immigrants is preferred as an explanation of faunal replacements across this unconformity.

STRATIGRAPHIC REVISION

Bonavista Group (revised)

The post-Random Lower Cambrian is not a continuous sequence in southeastern Newfoundland and the Bonavista "Formation" and lower part of the "Smith Point Limestone" are separated by unconformity surfaces from older units and from the overlying trilobite-bearing Lower Cambrian. At most localities, no evidence for unconformity exists between the Bonavista and lower Smith Point. Indeed, the initial nodular-appearing bedded limestones of the lower "Smith Point" overlie an interval of very similar calcareous nodules and thin-bedded limestones of the Bonavista at a number of localities (e.g. A, BSR, C1, Cu, GCo, Mo, RC, Rr, SP). At these localities (see Stop 7, Field Trip, this Bulletin), the contact between the Bonavista and "Smith Point" is transitional and is rather arbitrarily selected at the base of the limestone bed that marks the transition to where limestones are generally thicker than the intercalated siliciclastic mudstones (e.g. Fletcher, 1972, p. 167). Indications of unconformity or a diastem between these two units exists only at eastern localities in southern and eastern Trinity Bay and Conception Bay. This evidence includes a phosphatized surface immediately below the lower "Smith Point" at Long Cove (locality LC, see Stop 6, Field Trip, this Bulletin) and Hopeall Head where this phosphatization is weakly developed. Erosional relief occurs between the units at Bacon Cove and Brigus South Point (localities BC and BS) on western Conception Bay. The erosional relief reaches 32 cm at Brigus South Point (locality BS) and low spots on the underlying, locally calcified (pseudospar-impregnated) siliciclastic mudstones are mantled with dessication-cracked planar algalaminates. Coarse-grained calcite crystals impregnate the top of the shales below the "Smith Point" at Chapel Cove (locality CCo) and this development is comparable to that Brigus South Point although erosional relief is not observable at the contact. These pseudospars (as those at the base of the limestone at the top of member 4 of the Chapel Island Formation and at the top of the Random Formation under the Bonavista Group; Stops 4D and 6, Field Trip, this Bulletin) may have developed in the weathering profile of a soil.

The local offlap and shallowing prior to deposition of the lower part of the "Smith Point Limestone" are comparable to developments within and at the top of the regionally correlatable limestones lower in the Bonavista (Stops 6, 9A, Field Trip, this Bulletin).

Because this "natural" (i.e. unconformity-bounded) sequence forming the top of the sub-trilobitic Lower Cambrian is divisible into a sequence of formations, one of which (the Cuslett Formation) is divisible into members, and is a sequence with a relatively great local thickness(275 + m), it is accorded status as a "Group." The designation "Bonavista Group" is assigned to this interval. This designation is a *revision* (see North American Commission on Stratigraphic Nomenclature, 1983, Article 19) of the Bonavista "Formation" to include relatively minor changes in the unit's rank (to Group) and upper boundary (to include the lower part of the "Smith Point Limestone" below the regional unconformity). The second change involves inclusion of a meter of sub-trilobitic "Smith Point" at localities in western Placentia Bay (see Figure 36, localities BSR, Rr) and four to seven meters of the "Smith Point" in the thick (150-

275 + m) sections along the Placentia-Bonavista "axis" (Figures 36, 37).

The type section of the Bonavista Group is the east-dipping Cuslett section (locality Cu). This completely exposed, 149.9 m-thick section crops out on the south side of Cuslett Point and extends from the contact with the Random Formation at the end of Cuslett Point to the unconformable contact with the overlying trilobitic Lower Cambrian. This contact is at the top of the cliffs to the east of the small cove at the south side of the point. The type section of the Bonavista Group lies halfway between the hamlet of Cuslett to the northeast and Perch Cove to the south. The type sections of the Bonavista "Formation" and "Smith Point Limestone" (locality SP) are inappropriate as a composite type section for the Bonavista Group. Comparison with the nearby overlapping sections at Clifton and Petley (localities C1, P) indicates that about 80 m of section are covered between the base of the Bonavista Group at White Rock (locality WR, 9.0 m exposed) and the base of the section along Smith Point (see Figure 35).

The proposal of the "Bonavista Group" does not obviate the need for the Adeyton "Group" as a useful descriptor for the red, green, purple, and grey colored interval above the Random Formation and below the Manuels River Formation (Jenness, 1963). The Adeyton should be assigned a higher lithostratigraphic rank if used in regional and provincial syntheses.

Formations of the Bonavista Group

Petley Formation (*new*).—The lowest formation of the Bonavista Group is a relatively thin (up to 38 m) unit that crops out from the northern Bonavista Peninsula (locality K) and extends over 220 km to the south and southwest into Placentia Bay (localities DP, Cu). The Petley Formation unconformably overlies the Random and Chapel Island Formations at all known localities. The Petley Formation includes the strata above this unconformity to the top of a regionally extensive, stromatolitic, algal mud mound limestone that frequently has a hyolith wackestone cap (see Stop 6, Field Trip, this Bulletin). This (frequently) composite limestone bed is relatively thick (0.25-1.5 m). It is reddish pink to greenish pink in color and changes to a purplish pink in western Placentia Bay and Burin Peninsula localities (discussed above).

The Petley Formation is the coarsest-grained formation of the Bonavista Group. Characteristic lithologies include thin alternations of interbedded green to reddish, silty siliciclastic mudstones with calcareous nodules, lenticular (0-25 cm) conglomerates with pebbles of vein quartz, upper Precambrian clastics and igneous rocks. Cross-bedded, fine- to medium-grained quartz arenites, and local thin-bedded stromatolitic limestones and algal mud mounds with conoidal fossils occur in the Petley Formation.

The type section (Appendix 1) is located 0.35 km northwest of the wharf in the Village of Petley and is exposed as a shore cliff at the north end of the beach. The formation is named for the Village of Petley on Random Island.

West Centre Cove Formation (*new*).—The second formation of the Bonavista Group crops out from the northern Bonavista Peninsula (locality K) to the mouth of Placentia Bay (localities RC, DP). The West Centre Cove Formation (up to 79 + m-thick) is dominated by red, green, and local purple siliciclastic mudstones (typically bioturbated and structureless) with scattered calcareous nodules and rare bedded limestones that arise from the coalescence of nodules. The mudstones frequently contain abundant diagenetic chamosite grains; a late diagenetic chamositic rind often envelops the carbonate nodules (Stop 6, Field Trip, this Bulletin). The top of the West Centre Cove Formation is a stromatolitic, hyolith-rich, algal mud mound limestone unit that often consists of two limestones separated by a nodule-rich shale (Stops 6, 8A, 9B, Field Trip, this Bulletin) in northern and eastern localities. This limestone unit becomes a single bed of red, oncolitic, stromatolitic limestone in western Placentia Bay and the Burin Peninsula (localities DP, BSR, BI, JI, LI, Mo). The limestone at the top of the formation measures 0.5-3.1 m locally.

The base of the West Centre Cove Formation is commonly the top of the limestone forming the uppermost part of the Petley Formation. The Petley-West Centre Cove boundary interval often features a change in shale color from red (Petley) to green in the lowermost part of the West Centre Cove. The West Centre Cove Formation onlaps units as low as the upper part of the Musgravetown Group (locality RC) during its onlap east and west away from the Placentia-Bonavista "axis."

The type section of the West Centre Cove Formation (32.4 m-thick) overlies the limestone forming the top of the Petley Formation at the Sunnyside locality (Su). The type section extends east along the north shore of Bull Arm toward the mouth of Centre Cove (see Stop 6, Field Trip, this Bulletin and Figure 30). The formation is named for the hamlet of West Centre Cove at the head of Centre Cove; the type section lies 0.4 km SSE of West Centre Cove.

Cuslett Formation (new).—The third and thickest formation of the Bonavista Group (up to 201.5 m-thick) directly overlies the limestone bed forming the top of the West Centre Cove Formation along the Placentia-Bonavista "axis." It onlaps east into western St. Mary's Bay and western Conception Bay (localities (BS, BC, CD, Sa) across the eroded top of the Random Formation and older units. The top of the Cuslett Formation is defined by the base of the Fosters Point Formation (new).

The Cuslett Formation is dominated by red, purple, green and minor grey and black siliciclastic mudstones with microspar nodules. Bedded, reddish, typically thin (5-35 cm) limestones are intercalated with red and purple siliciclastic mudstones in the middle part of the formation (Stops 6, 8) in Placentia, western Trinity, and eastern Trinity Bays. These limestones are commonly fossiliferous wacke- to packstones with local development of low algal mud mounds. Limestones of this type do not occur in the underlying Petley and West Centre Cove Formations. The upper part of the formation is a characteristic purple to green siliciclastic mudstone on the eastern side of the Placentia-Bonavista "axis." These latter mudstones feature abundant *Teichichnus* burrows, small calcareous nodules, and small, calcified, isolated (e.g. lenticular) ripples of very fine-grained quartz sand.

The type section of the Cuslett Formation (Appendix 2) is located on the south side of Cuslett Point and extends from the top of the limestone cap of the West Centre Cove Formation to the base of the Fosters Point Formation. The four informal members of the formation described at Sunnyside (Stop 6, Field Trip, this Bulletin) are recognizable in the 110.4 m-thick type section of the Cuslett Formation at locality Cu. The formation is named for the hamlet of Cuslett located 1.4 km to the northeast.

Fosters Point Formation (new).—The Fosters Point Formation (up to 13 m-thick) overlies the Cuslett Formation along the Placentia-Bonavista "axis" and unconformably onlaps the Random Formation in St. Mary's Bay (locality JC). The Fosters Point Formation is the lower part of a stratigraphically composite, ridge-forming, red limestone (= "Smith Point Limestone") that represents the amalgamation of sub-trilobitic limestones and shales (= Fosters Point Formation) and the basal beds of the Brigus Formation (revised). In many sections, the Fosters Point is transitional upward from the underlying Cuslett Formation and its base is selected as the first limestone that is part of the interval where limestones are thicker than intervening shales. The top of the Fosters Point Formation is defined by the base of the Brigus Formation (emended).

The type section of the Fosters Point Formation is 7.0 m-thick and is located immediately east of the government wharf at Smith Point. This locality lies on the shore down the hill from the east end of the village of Harcourt. In the past, the settlement above Smith Point was known as Fosters Point (see also Jenness, 1963, Map 1130A) and the designation "Fosters Point Formation" is taken from the traditional name for this settlement.

The type section of the Fosters Point Formation shows the characteristic nodular-appearing limestones, algal mud mounds, hyolith-oncolite-intraclast (rare) wacke- to packstone beds and associated nodular red shales of the unit (Stop 7, Field Trip, this Bulletin, see Figure 31 for illustration of type section). As noted by Landing and Benus (1984), algal mud mounds decrease as a major component of the formation east of the west Trinity Bay area, and the formation becomes thinner bedded with more abundant oncolites and thin, storm-washed conoidal horizons. These types of lithologies characterize the east Trinity Bay, and west Conception and St. Mary's Bay regions and are the near-shore facies of the formation. The limestones and intercalated siliciclastic mudstones of the formation are generally reddish in color (pink to brick red). The only exception are the localities in southern Conception Bay (CCo and D) where the formation is medium to dark grey in color because of a relatively high phosphate content.

The thickest sections of the formation occur in western Trinity Bay where the Fosters Point Formation reaches a thickness of 13.25 m at Heart's Desire and Heart's Delight (localities HD and HeD). The formation thins towards the west where it has thicknesses of 5-7 m in the region of the Placentia-Bonavista axis.

Considerable thought has been given to the proposal of the Fosters Point Formation because this involves abandonment of the well-established designation "Smith Point Limestone." However, the "Smith Point" everywhere represents parts of two independent depositional sequences. As discussed above, the upper part of the "Smith Point" at northern localities, including Smith Point itself, is actually the lateral equivalent of siliciclastic mudstones and nodular carbonates located more than 17 m above the base of the Brigus Formation at Redland Cove.

The restriction of the "Smith Point Limestone" to the subtrilobitic limestone interval at the top of the Bonavista Group is considered to be an "undesirable restriction" (North American Commission on Stratigraphic Nomenclature, 1983, Article 19g). In order to avoid confusion, subsequent reports would have to designate whether the "original concept" or a "modified usage" was being applied. The modified usage would mean that less than half of the original "Smith Point" would be referable to the modified "Smith Point" (see locality Rr).

Brigus Formation (emended)

The concept of the Brigus Formation is unchanged from that of previous reports (see Hutchinson, 1962; Jenness, 1963; Fletcher, 1972) except that the lower boundary is moved downward (locally 0.0-2.0 m) to the unconformity at the top of the Fosters Point Formation; this assigns the trilobite wacke- to packstones, locally oncolitic and stromatolitic, that frequently overlie the Foster's Cove Formation to the Brigus Formation. As discussed above, the unconformity separating the limestones of these two formations may be recognized by the field geologist by a thin quartz sand or siliciclastic pebble horizon, a planar stromatolite horizon, truncated oncolites, erosional relief, or by an abrupt transition from fine-grained algal mud mound limestone to an overlying limestone bearing trilobite fragments as allochems. In addition, a distinctive, thin (0-10 cm-thick), bluish-weathering, diagenetic pseudospar or a bluish, manganese stained bedded limestone ("blue bed" of Landing and Benus, 1984) frequently appears immediately below the lowest trilobite-bearing limestone (localities B, BS, HD, HeD, Mo, Sa, SP; see Stop 7, Field Trip, this Bulletin). Several additional aids for recognizing the contact of these formations include a local limonite-encrusted upper surface of the Fosters Point Formation (localities A, SP) and the extreme rarity of large hyoliths in the basal trilobite-bearing limestones of the Brigus Formation and their abundance in the Fosters Point Formation. In addition to being compositionally dissimilar to the Fosters Point Formation, the overlying limestones of the lowest part of the Brigus Formation tend to weather white to light pink rather than a deep reddish pink.

Definition of the Fosters Point Formation and emendation of the Brigus Formation have the consequence of assigning all Lower Cambrian trilobite-bearing limestones and associated siliciclastics to the Brigus Formation in southeastern Newfoundland. This allows a more consistent lithostratigraphic practice than the traditional procedure of assigning the lowest trilobite-bearing limestone to the Brigus if it unconformably rests on Random and older units (localities LDC', Mr, TS; see Hutchinson, 1962) while referring coeval beds to the top of the "Smith Point Limestone" where the unconformity with subtrilobitic rocks lies within a limestone sequence. This stratigraphic revision should pose few problems in mapping in southeastern Newfoundland. The contact between the Bonavista Group (and Fosters Point Formation) with the overlying Brigus Formation lies within the upper part of the "Smith Point Limestone" at most localities or at the very top of the "Smith Point" (at locality BSR). The field geologist simply locates the lowest horizon with trilobites in the "Smith Point;" any error in selecting this boundary is of no significance at map scales. In any case, there are relatively few localities where the "Smith Point" crops out in southeastern Newfoundland and criteria for locating the Fosters Point-Brigus contact at most localities have been listed above. Figures 35 and 36 show the thickness of the basal, trilobite-bearing limestone of the Brigus Formation at most localities of the "Smith Point." We will be providing detailed sections of the Fosters Point – lower Brigus interval at all known localities in a subsequent publication.

DISCUSSION

Lithologic uniformity

Hutchinson's (1962) opinion that a uniform stratigraphic nomenclature is applicable in southeastern Newfoundland is confirmed by the relative ease of detailed lithostratigraphic correlation of the upper sub-trilobitic and lowest trilobite-bearing Lower Cambrian. Hutchinson's (1962, p. 13) only apparent error in application of the Trinity-Conception Bay stratigraphic succession was in reporting a 2.4 m-thick outcrop of "Smith Point" at the head of Burin Bay Arm (locality BI). This outcrop is actually a thrust-duplicated marker bed (1.05 m-thick) in the upper part of the Brigus Formation in the eastern Burin Peninsula.

An alternative stratigraphic nomenclature for the Cambrian of the southeastern and southern Burin Peninsula is not necessary. In this region, Strong *et al.* (1978) proposed the "Inlet Group" and named a sequence of formations within the "Inlet." The "Salt Pond Formation" is simply the Brigus Formation at Salt Pond while the West Center Cove, Cuslett, Fosters Point and Brigus formations are recognizable within the "Salt Pond" along Burin Inlet (see locality BSR). Similarly we have examined a discontinuously-exposed section on the north limb of the syncline at Big Salmonier River (1.8 km north of BSR) that includes the Brigus Formation and the overlying "Pleasant View Formation." The latter "formation" includes the Chamberlains Brook and Manuels River formations. The lowest unit of the "Inlet Group," the "Bay View Formation," is the Chapel Island Formation at Duck Point and Burin Inlet (localities DP, BI).

Correlation using marker limestones within the Bonavista Group requires a re-interpretation of Bengtson and Fletcher's (1983) stratigraphy at Duck Point. The Chapel Island Formation-Bonavista Group unconformity does not fall within the second stromatolitic limestone; indeed this bed is the top of the West Centre Cove Formation. Bengtson and Fletcher's (1983) first limestone is not within the Chapel Island Formation but represents an amalgamation of the limestone at the top of the Petley Formation with the basal onlap limestone at the base of the Petley Formation. Reworked pebbles and cobbles of Chapel Island siltstones and nodules, quartz and feldspar granules, and Burin Group volcanic fragments occur at the base of this bed (see Figure 36).

The higher strata above the stromatolitic, second limestone at Duck Point belong to the Cuslett Formation. Bengtson and Fletcher's (1983, p. 530) nodular limestones "44 m above the stromatolitic limestone" belong to "member 2" of the Cuslett Formation while the limestones "occurring between 85 and 115 m" belong to "member 3." The upper part of the Duck Point section represents the *Teichichnus*-rich facies of "member 4." The Fosters Point Formation can be predicted to lie just below low tide at the top of the accessible section.

Limestones as onlap/offlap markers

Bedded limestones represent the shallowest-water lithologies of the Bonavista Group and Brigus Formation. Lime-

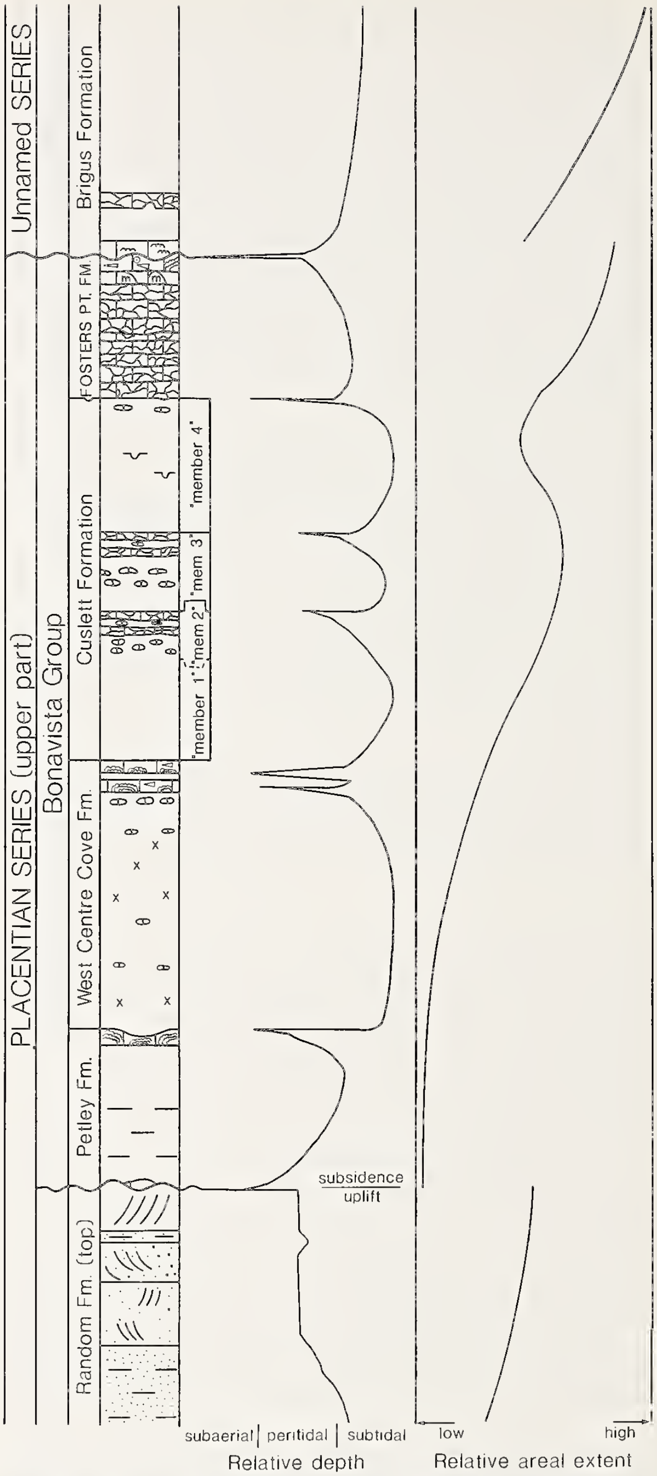


Figure 37. Interpreted onlap-offlap cycles during deposition of the Bonavista Group and lowest part of the Brigus Formation. Section not to scale; figure represents stratigraphy along the western Trinity Bay, northern Bonavista Peninsula, and Placentia Bay regions. Symbols: X = chamosite; wavy lines within limestones, stromatolites; elongate triangles, large hyoliths; nodular-appearing limestones figured in members 2 and 3 of the Cuslett Formation and Foster's Cove Formation; "m" is algal mud mound; U-shaped symbols in member 4 of Cuslett Formation, *Teichichnus*; trilobite symbols in lower bed of Brigus Formation.

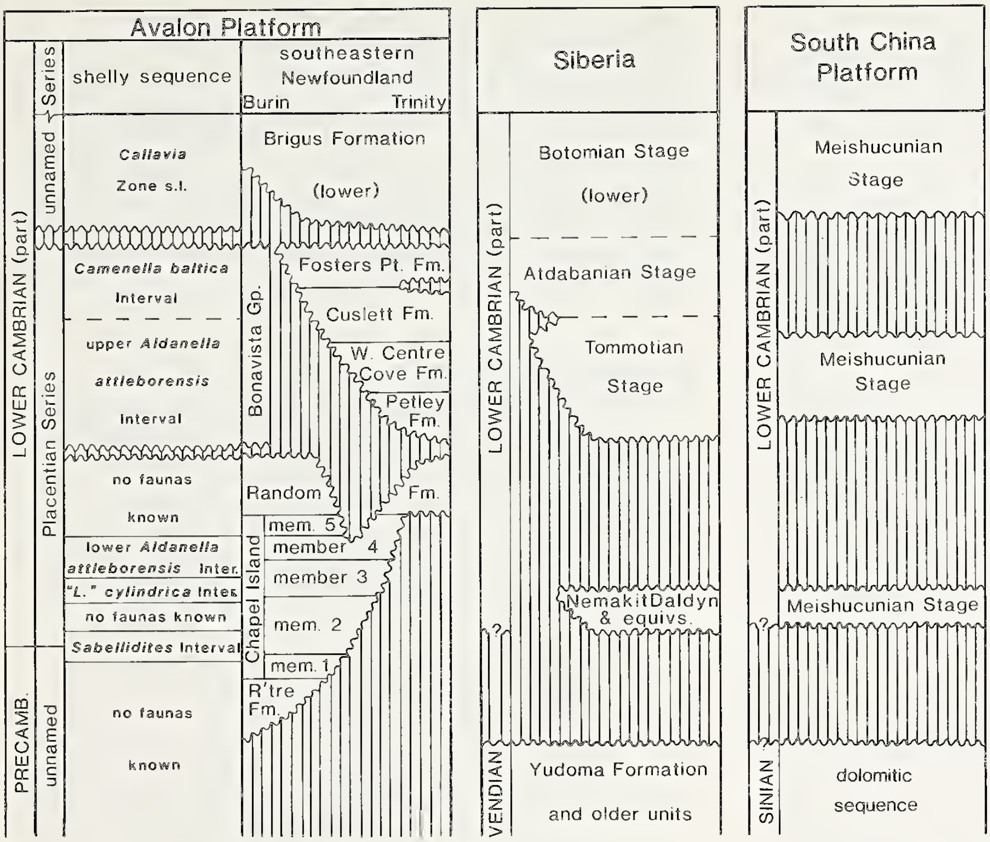


Figure 38. Lithostratigraphy and proposed correlations of the uppermost Precambrian and Lower Cambrian of southeastern Newfoundland (modified from Landing, In press). The transition from the upper *Aldanella attleborensis* assemblage to the overlying *Camenella baltica* assemblage is controlled by regional shoaling and the appearance of bedded limestones of member 2 of the Cuslett Formation.

stones are frequently the initial deposits of the Bonavista and Brigus onlaps and directly overlie unconformity surfaces (see Figures 35, 36). Large hyoliths, oncolites, stromatolites and algal mud mounds, wave winnowed shell hash, and associated land-derived clastics characterize these shallow shore-line deposits (e.g. King and Anderson, 1982; base of Brigus at Stop 5, this Bulletin). As discussed above, the limestone tops of the Petley and West Centre Cove Formations show very comparable lithologic developments (Stops 6, 8A, 9A, Field Trip, this Bulletin). The appearance of these formational markers in sections of the Bonavista Group represent the temporary development of shoreline deposits in the shale-dominated sequences of the Bonavista Group and are equated with offlap (Figure 37). The very fossiliferous caps of these limestones (Stop 6, Field Trip, this Bulletin) may record the onset of subsequent onlap and the appearance of less restricted marine conditions.

The limestone intervals at the top of the Petley Formation and West Centre Cove Formation have a very similar sequence of facies: a) appearance of abundant carbonate nodules in siliciclastic mudstones (= onset of offlap), b) development of peritidal limestone bed (maximum offlap), c) deposition of fossil packstone cap, and d) abrupt contact with nodule-poor shale. The very uniform internal stratigraphy within these intervals and an absence of erosional modification or cut-out towards the eastern and western areas of the Placentia-Bonavista "axis" suggests that offlap was relatively rapid in this shallow, level-bottom shale basin. These limestones are regarded as practical isochrons for correlation.

Facies control on biostratigraphy

Bedded limestones become abundant in the middle part of the Cuslett Formation and define members 2 and upper member 3 of the formation. In addition, the Fosters Point Formation represents the basin-wide spread of a carbonate lithosome. Our study of these limestones (in prep.) indicates that they represent relative shoalings of the shale basin in southeastern Newfoundland. Through this same time interval, the upper part of the Bonavista Group was spreading east and west of the Placentia-Bonavista "axis." Thus, these units are areally extensive but, paradoxically, represent the shallow-water facies that would be expected with regional offlap (Figure 38). Algal mud mounds, stromatolitic laminae, shell hash tempestites, bird's-eye fabric, local intraclast lenses and other features in upper member 3 of the Cuslett Formation and Fosters Point Formation point to higher-energy, shoal-water environments (in prep.).

The appearance of the limestones defining member 2 of the Cuslett Formation coincides with the lowest record of the *Camenella baltica* assemblage (including *C. baltica*, *Pojetaia*? *terranovica*, and the lower part of the "acme" of *Coleoloides typicalis*). These forms are joined by *Rhombocorniculum insolutum* and *R. cancellatum* and *Gracilitheca* in member 3. This complex of species (referred to as the "*Coleoloides typicalis* assemblage," Bengtson and Fletcher, 1983) probably indicates that this interval of the Bonavista Group is equivalent to the upper part of the Tommotian Stage or lower Atdabanian Stage of Siberia (Bengtson and Fletcher, 1983; Landing, In Press). However, the *Camenella baltica* assemblage appears above the upper *Aldanella attleborensis* assemblage of the lower part of the Bonavista Group with the development of a regionally extensive, shallow water, mixed siliciclastic-carbonate facies. This is a linked lithofacies and biofacies shift that should be regarded as an environmental change and immigration event. The appearance of the *Camenella baltica* assemblage over an underlying upper *Aldanella attleborensis* assemblage in southeastern Newfoundland and eastern Massachusetts should be regarded as of little use in precise interregional correlation (Landing, In Press).

Tectonic evolution

Deposition of the Bonavista Group and Brigus Formation followed an important interval of block faulting that resulted in partial to locally complete erosion of the Random Formation. Differential, geographically restricted, long-term subsidence defined the Placentia-Bonavista axis, and this elongate, north-trending structure received the thickest accumulation of the Petley through Cuslett Formations of the Bonavista Group. However, the thickest sections of the Fosters Point Formation lie in eastern Trinity Bay to the east of the Placentia-Bonavista axis. An easterly shift of the Lower Cambrian depocenter occurred during accumulation of the Brigus Formation, and maximum thicknesses of the Brigus lie along an axis following central Trinity and St. Mary's bays (Hutchinson, 1962; authors, unpub. data). The seemingly sequential development of a post-Random depocenter along the Placentia-Bonavista axis and its shift to the east as well as the presence of sediment-filled joints below the Petley through Fosters Point Formations in easterly outcrops may be related phenomena that reflect changes in the action of an extensional regime. The onlap of the post-Random Lower Cambrian in southeastern Newfoundland (as well as other Avalonian regions) may be driven primarily by local tectonic mechanisms rather than by eustatic rise or changes in rate of eustatic rise.

ACKNOWLEDGMENTS

The authors are indebted to the National Geographic Society (grants 2453-82 and 2616-83) and the National Science Foundation (grant EAR83-12939) for the opportunity to undertake this research in southeastern Newfoundland. Various aspects of this report were discussed with J. D. Aitken, M.M. Anderson, and W. Fritz. J.D. Aitken, M.A.S. McMenamin, and G.S. Nowlan reviewed the manuscript.

REFERENCES CITED

Anderson, M.M. 1987. Stratigraphy of Cambrian rocks at Bacon Cove, Duffs, and Manuels River, Conception Bay, Avalon Peninsula, eastern Newfoundland. Geol. Soc. Amer., Centennial Field Guide-Northeastern Section, pp. 467-472.

Bengtson, S. and Fletcher, T.P. 1983. The oldest sequence of skeletal fossils in the Lower Cambrian of southeastern Newfoundland. Canadian J. Earth Sci. 20:525-536.

Christie, A.M. 1950. Geology of Bonavista Map-area, Newfoundland. Geol. Surv. Canada, Pap. 50-7, 40 p.

Crimes, T.P. and Anderson, M.M. 1985. Trace fossils from late Precambrian-Early Cambrian strata of southeastern Newfoundland (Canada): Temporal and environmental implications. J. Paleo. 59:310-343.

Fletcher, T.P. 1972. Geology and Lower to Middle Cambrian trilobite faunas of the southwest Avalon, Newfoundland. Unpub. Ph.D. diss., Univ. of Cambridge, 469 p.

Greene, B. and Williams. H. 1974. New fossil localities and the base of the Cambrian in southeastern Newfoundland. Canadian J. Earth Sci. 11:319-323.

Hiscott, R.N. 1982. Tidal deposits of the Lower Cambrian Random Formation, eastern Newfoundland: Facies and paleoenvironments. Canadian J. Earth Sci. 19:2028-2046.

Hutchinson, R.D. 1962. Cambrian stratigraphy and trilobite faunas of southeastern Newfoundland. Geol. Survey Canada, Bull. 88, 156 p.

Ingen, G., van. 1914. Table of geological formations of the Cambrian and Ordovician Systems about Conception and Trinity Bays, Newfoundland. Princeton Univ., Contrib. Geol. Newfoundland, No. 4, 1 p.

Jenness, S. E. 1963. Terra Nova and Bonavista Map-areas, Newfoundland (2 D E1/2 and 2C). Geol. Surv. Canada, Mem. 327, 184 p.

King, A. F. and Anderson, M.M. 1982. Bacon Cove unconformity and tillite, pp. 58-60. *In* The Caledonide Orogen, Guidebook for Avalon and Meguma Zones. *Edited by* King, A. F. NATO Advanced Study Institute, Atlantic Canada, St. John's, 308 p.

Landing, E. In press. Lower Cambrian of eastern Massachusetts: Stratigraphy and small shelly faunas. J. Paleont.

__________ and Benus, A. P. 1984. Lithofacies belts of the Smith Point Limestone (Lower Cambrian, eastern Newfoundland) and the lowest occurrence of trilobites. Geol. Soc. Amer. Abst. Prog. 16:45.

Ludvigsen, R. and Westrop, S. R. 1983. Trilobite biofacies of the Cambrian-Ordovician boundary interval in northern North America. Alcheringa 7:301-319.

McCartney, W. D. 1969. Geology of Avalon Peninsula, southeast Newfoundland, pp. 115-129. *In* North Atlantic-Geology and Continental Drift. *Edited by* Kay, M. Amer. Assoc. Petrol. Geol., Mem. 12, 1082 p.

Narbonne, G. M., Myrow, P., Landing, E., Anderson, M. M. 1987. A candidate stratotype for the Precambrian-Cambrian boundary, Fortune Head, Burin Peninsula, southeastern Newfoundland. Canadian J. Earth Sci. 24:

North American Commission on Stratigraphic Nomenclature. 1983. North American stratigraphic code. Amer. Assoc. Petrol. Geol. Bull. 67:841-875.

O'Brien, S. J. and Taylor, S. W. 1983. Geology of the Baine Harbour (1M/7) and Point Enragee (1M/6) map areas, southeastern Newfoundland. Mineral Dev. Div., Dept. Mines Energy, Govt. Newfoundland Labrador, Rept. 83-5, 70 p.

Strong, D. F., O'Brien, S. J. O., Taylor, S. W., Strong, P. G., Wilton, D. H. 1978. Geology of the Marystown (1M/3) and St. Lawrence (1L/14) map areas, Newfoundland. Mineral Dev. Div., Dept. Mines Energy, Govt. Newfoundland Labrador, Rept. 77-8, 81 p.

Walcott, C. D. 1900. Lower Cambrian terrane in the Atlantic Province. Proc. Washington Acad. Sci. 1:301-399.

APPENDIX 1: TYPE SECTION OF THE PETLEY FORMATION

	Unit Thickness (m)	Total Thickness (m)
West Centre Cove Formation		
Red siliciclastic mudstones, structureless, abruptly overlie top of Petley Formation	3.0 +	3.0 +
Petley Formation (type section)		
Limestone unit, composite bed with (from base) a) red nodular limestone (10 cm), b) planar stromatolite layer (5 cm), c) hyolith-oncolite grainstone (15 cm), d) Fe-Mn impregnated "*Collenia*"-type stromatolites (2 cm), e) purple siliciclastic mudstone (3 cm), f) purple siliciclastic mudstone with nodules (10 cm), g) white lime mudstone with upper corrosion surface (ca. 10 cm), h) pink hyolith-oncolite wackestone with small domal stromatolites at contact with unit g (10-15 cm), i) unit identical to unit h with small domal stromatolites on top of unit h, j) red siliciclastic mudstone (2-4 cm), k) pink to white lime mudstone (8-9 cm)	0.8	19.8
Red siliciclastic mudstone	0.01	19.0
Purplish-red siliciclastic mudstone with green reduction spots	2.15	18.99
Grey siliciclastic mudstone	0.04	16.84
Bluish-green siliciclastic mudstone with white calcareous nodules, mm-thick quartz sand laminae rare, scattered pyritohedrons	13.0	16.8

Green, sandy siliclastic mudstone with red calcareous nodules and thin calcareous quartz arenites	0.93	3.8
Bluish green siliciclastic mudstone with cross-bedded cm-thick sand from base	1.78	2.87
Green, cross-bedded quartz arenite with flaser bedding	0.52	1.09
Green siliciclastic mudstone	0.08	0.57
Limestone, stromatolitic at top, lower is arenaceous pink microsparite	0.29	0.49
Calcareous quartz arenite, green grey, with siltstone pebbles	0.20	0.20
Random Formation		
Purple cross-laminated siltstones		

APPENDIX 2: TYPE SECTION OF THE CUSLETT FORMATION

	Unit Thickness (m)	Total Thickness (m)
Fosters Point Formation		
Red, cliff-forming limestones and thin nodular siliciclastic mudstones	7.5	7.5
Cuslett Formation (type section)		
member 4		
d) Red siliciclastic mudstones with abundant nodules and several limestone beds (10 cm-thick, abundant *Teichichnus*	4.5	110.4
c) Alternations of red and purple siliciclastic mudstones form assymmetrical cycles with lower purple mudstones grading upward into red, nodular mudstones and frequently, nodular limestone cap; purple mudstones abruptly overlie red	8.75	105.9
b) Purple siliciclastic mudstone, abundant *Teichichnus* and isolated fine sand ripples	7.92	97.15
a) Alternations of red and purple mudstones as unit C, base of member 4 at top of highest continuous limestone bed in member 3	5.93	89.13
member 3		
c) Red and purple siliciclastic mudstones in asymmetrical cycles (0.5-2.0 m-thick), lower nodular purple mudstone grades into overlying nodular red mudstone with 10-20 cm-thick, fossil wackestone bed at top, purple siliciclastic mudstone abruptly overlies limestone cycle cap.	34.35	83.20
b) Red and purple siliciclastic mudstones as unit c but carbonatecycle caps are nodular bedded limestones	7.15	48.35
a) Purple siliciclastic mudstones with very rare, small calcareous nodules	3.49	41.20
member 2		
Reddish-purple siliciclastic mudstones, nodular, with several thin fossil wackestone beds, base of first bedded limestone used to define member's base, top of member 2 is top of highest bedded limestone under member 3 (base of member coincides with appearance of *Camenella baltica assemblage*).	5.29	37.71
member 1		
d) Purple siliciclastic mudstones with mm- to cm-thick quartz arenites, laminated throughout	12.07	31.42
c) Red siliciclastic mudstones with scattered calcareous nodules	1.25	19.35
b) Purple siliciclastic mudstones as unit d but with local green (reduction) spots	10.00	18.10
a) Purple and red siliciclastic mudstones in 2-3 m-thick alternations with nodular carbonates; purple mudstone at base rests abruptly on 0.8-1.1 m-thick limestone forming top of West Centre Cove Formation.	8.10	8.10
West Centre Cove Formation	21.0	21.0
Petley Formation	11.0	11.0
Random Formation	section not measured	

Trace Fossil Biostratigraphy in the Precambrian-Cambrian Boundary Interval

Guy M. Narbonne[1] and Paul Myrow[2]

[1] Department of Geological Sciences, Queen's University
[2] Department of Earth Sciences, Memorial University (present address: Geology Department, Colorado College)

ABSTRACT

Rapid early evolution, widespread distribution, lack of provincialism and lack of post-mortem transport make trace fossils an ideal group to use for definition and correlation of the Precambrian-Cambrian boundary. Previous analyses have concentrated on identifying low diversity (Precambrian) versus high diversity (Cambrian) assemblages; however, more recent zonal schemes provide greater stratigraphic resolution and are less influenced by environmental factors. Sub-trilobitic strata of the Burin Peninsula (Chapel Island and Random formations) have abundant trace fossils that can be used to define three globally-recognizable trace fossil zones. In ascending order, these are: *Harlaniella podolica* Zone (uppermost Precambrian), *Phycodes pedum* Zone (lowest Cambrian) and *Rusophycus avalonensis* Zone (Lower Cambrian). Small shelly fossils in the Burin Peninsula sections and trace fossil correlation into the East European Platform and Siberia imply that, in these sections, the first appearance of Cambrian-type trace fossils (*i.e. Phycodes pedum* Zone) predates the base of the Tommotian and approximately corresponds to the first appearance of shelly fossils (e.g. Rovno- and Nemakit Daldyn-type assemblages).

INTRODUCTION

Although ichnologists have generally regarded trace fossils as the ideal fossil group for use in recognition of the Precambrian-Cambrian boundary, the concept had little support until recently outside the trace fossil community. Much of the earlier indifference towards trace fossils was a logical extension of the promise initially shown by small shelly fossils in zoning the carbonate facies of central Asia. Both trace fossils and small shelly fossils show rapid evolution in the Precambrian-Cambrian boundary interval. Trace fossils have one obvious disadvantage over shelly fossils – they do not represent part of the organism itself but rather its track, trail or burrow. However, trace fossils have several advantages over shelly fossils that are particularly relevant to studies in the Precambrian-Cambrian boundary interval.

1) *Facies Distribution.*–In the boundary interval, trace fossils and small shelly fossils show an almost antipathetic relationship; trace fossils are most common in siliciclastics whereas small shelly fossils are virtually restricted to carbonates, especially phosphatic carbonates (Stanley, 1976, p. 68). Consequently, the carbonate facies of central Asia are zoned primarily on the basis of small shelly fossils and archaeocyathans. Trace fossils occur sporadically in carbonate facies and can be used to zone strata in China (Jiang *et al.*, 1982; Crimes and Jiang, 1986) and Siberia (Fedonkin, this Bulletin) but are overshadowed by the abundant small shelly fossils in these sections. However, siliciclastic facies are predominant in the Precambrian-Cambrian boundary interval throughout most of the rest of the world, including North America, South America, Europe, Australia and southern Africa (Rozanov, 1984, Fig. 1). Small shelly fossils occur very sporadically and typically are poorly preserved in these areas. In most sections, abundant small shelly fossils first appear only considerably above the boundary and are associated with the onset of widespread, late Early Cambrian carbonate deposition (cf. Brasier, 1979). Consequently, other criteria (*e.g.* trace fossils and acritarchs) must be used to recognize the PrecambrianCambrian boundary in these areas (see Figure 39).

2) *Lack of provincialism.*–Marked provincialism characterizes Early Cambrian shelly fossils (e.g. Cowie, 1971; Jiang, 1984) and results in problems in global correlation. In contrast, late Precambrian and Early Cambrian trace fossils are cosmopolitan, and most of the diagnostic ichnogenera have been reported from every continent except Antarctica (cf. Crimes, 1987; see also Figure 40).

3) *Lack of secondary transport.*–Shelly fossils, especially small shelly fossils, are subject to post-mortem transport. They can be reworked into younger deposits or can infiltrate into older deposits (see discussions in Cowie and Rozanov, 1974, p. 239; Cowie, 1985, p. 96). In contrast, trace fossils are not subject to reworking; the exceptions are both obvious and rare.

PREVIOUS WORK

Ever since the work of Seilacher (1956) it has been recognized that upper Precambrian strata contain low diversity trace fossil assemblages that are dominated by simple forms while Lower Cambrian strata contain high diversity assemblages that include complex burrows and arthropod traces. Studies of Precambrian-Cambrian deposits worldwide all show significant, typically abrupt, upward increases in trace fossil diversity (see reviews in Alpert, 1977; Byers, 1982; Crimes, 1987; Narbonne *et al.*, 1987). A total of 15 ichnogenera have been reported from upper Precambrian strata whereas nearly 50 ichnogenera occur in sub-trilobite Lower Cambrian strata (Crimes, 1987). Alpert (1977) recommended that the first appearance of arthropod traces and/or complex burrows be used to define the Precambrian-Cambrian boundary, a view supported by most ichnologists. However this criterion must be used with caution because lithologic and/or environmental factors can also affect trace fossil diversity (Crimes *et al.*, 1977). The absence of a zonal scheme for trace fossils and the failure to correlate the trace fossil diversification with the shelly fossil assemblages of carbonate facies have further hindered the use and acceptance of Alpert's proposal (Byers, 1982).

The first zonal scheme for boundary-interval trace fossils was proposed for the Meishucun section (Jiang *et al.*, 1982). Four zones were recognized; in ascending order these include the *Sellaulichnus meishucunensis*, *Cavaulichnus viatorus*, *Didymaulichnus miettensis*, and *Plagiogmus arcuatus* Zones. The upper two zones contain several Cambrian-type ichnofossils (Crimes and Jiang, 1986). However, the lower two zones are based on non-diagnostic and/or poorly preserved specimens, and neither *Sellaulichnus* nor *Cavaulichnus* have been recognized outside of their type section at Meishucun. Consequently, these trace fossil zones may be locally significant but cannot be used globally.

The first truly global trace fossil zonation was proposed by T. P. Crimes (1987), who recognized three zones of uppermost Precambrian and lowermost Cambrian (sub-trilobite) trace fossils:

> Zone I: Upper Precambrian (Vendian)
> Simple, subhorizontal traces. A few ichnogenera (e.g. *Harlaniella*, *Palaeopaschichnus*, *Nenoxites*) apparently restricted to this zone. Approximately 15 ichnogenera known.
>
> Zone II: Basal Cambrian
> First appearance of complex feeding burrows (e.g. *Phycodes*, *Teichichnus*, *Treptichnus*). Approximately 25 ichnogenera known.
>
> Zone III: Lower Cambrian
> First appearance of arthropod burrows (e.g. *Rusophycus*, *Cruziana*) and spreiten dwelling-burrows (e.g. *Diplocraterion*). Approximately 45 ichnogenera known.

Crimes (1987) believed that these zones were globally significant, a view supported by our independent and largely simultaneous study of the Chapel Island Formation.

SOUTHEASTERN NEWFOUNDLAND

Data base

Crimes and Anderson (1985) carried out a member-by-member study of the trace fossils at the Chapel Island and Random formations. They observed an upwards increase in

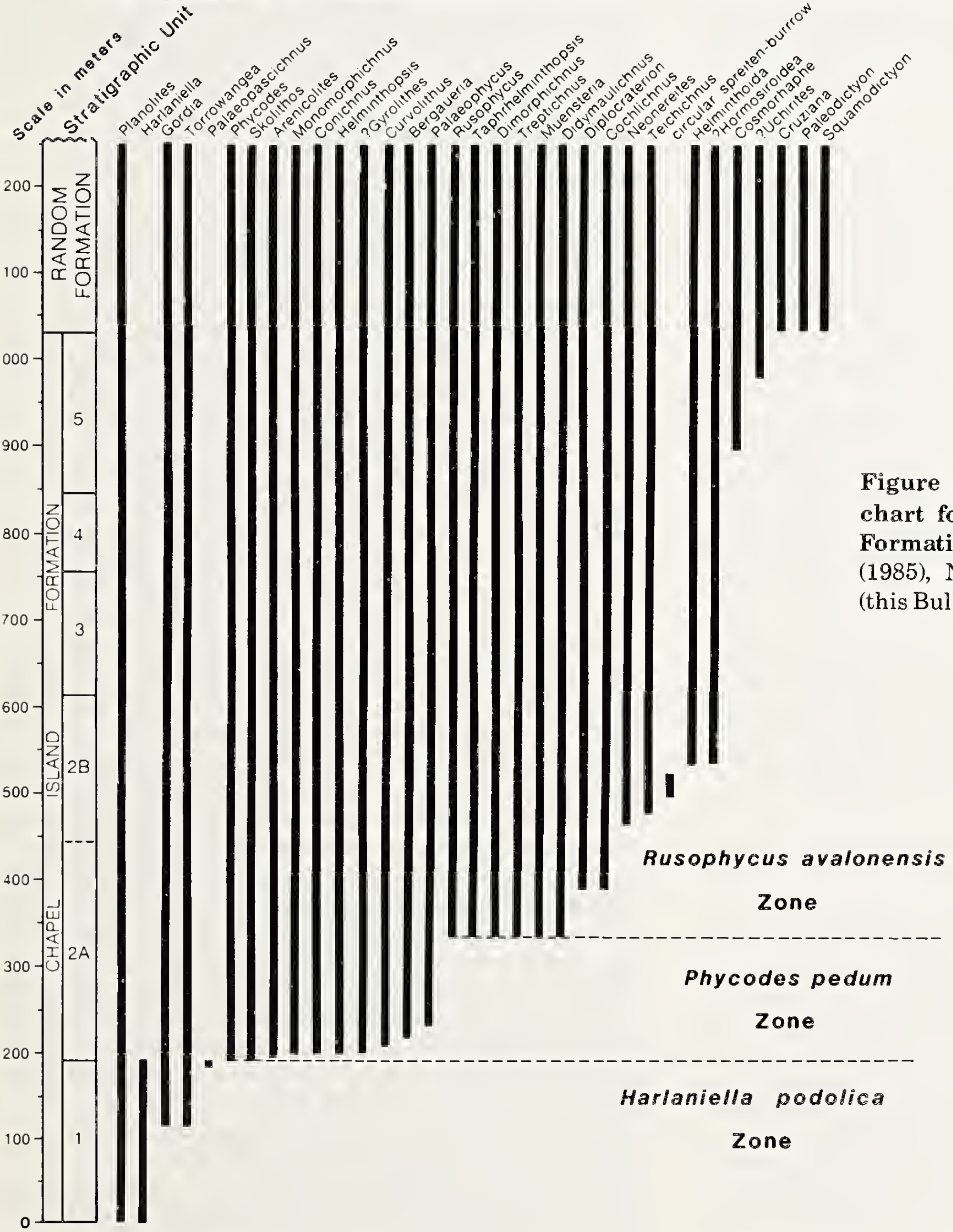


Figure 39. Generalized trace fossil range chart for the Chapel Island and Random Formations. Data from Crimes and Anderson (1985), Narbonne *et al.* (1987) and Field Guide (this Bulletin) (stops 2-4).

trace fossil diversity through the sequence with the first complex feeding burrows appearing in member 2 of the Chapel Island Formation and the lowest well-developed arthropod burrows occurring in the Random Formation. Based on this study, Crimes and Anderson (1985)) concluded that the Precambrian-Cambrian boundary occurs at or near the contact between members 1 and 2 of the Chapel Island Formation.

Narbonne *et al.* (1987) carried out a bed-by-bed study of all available sections through the Chapel Island Formation of the Burin Peninsula. This study included several sections (notably Fortune Head) not examined by previous workers. Detailed logs of some of these sections are presented in the Field Trip section of this Bulletin. This information can be combined with data from Narbonne *et al.* (1987, Fig. 4) and Crimes and Anderson (1985, Fig. 15) to produce a generalized range chart for the Chapel Island – Random interval (Figure 39).

Narbonne *et al.* (1987) recognized three distinct trace fossil zones in this succession, comprising (in ascending order) the *Harlaniella podolica*, *Phycodes pedum*, and *Rusophycus avalonensis* Zones. The composition, global correlation and age of each of these zones is discussed below.

Harlaniella podolica Zone

This zone characterizes member 1 and the basal 2.4 m of member 2 of the Chapel Island Formation. It is defined as the range zone of *Harlaniella podolica* and also represents the upper half of the range zone of *Palaeopascichnus delicatus*. It is characterized by a low diversity (less than 10 ichnospecies) assemblage of simple, subhorizontal trails and burrows constructed at or near the sediment-water interface. The zone is widespread (Figure 40); in addition to the occurrences of *H. podolica* shown (dark dots) in this figure, *Palaeopascichnus delicatus* occurs in the Lublin Formation of Poland (Paczesna, 1985, 1986), the Redkino and Kotlin "Horizons" of the Russian Platform (Palij *et al.*, 1979; Fedonkin, 1985), and the Yudoma Formation of Siberia (Fedonkin, this Bulletin). Other occurrences shown in Figure 40 represent the "low diversity" or "Precambrian-type" assemblages of previous authors and do not contain definite Precambrian fossils.

The *Harlaniella podolica* zone is equivalent to the upper half of Crimes' (1987) Ichnofossil Zone I. It is of latest Precambrian age and approximately corresponds to the Kotlin "Horizon" (upper Valdai 'Series') of the East European Platform. *H. podolica* has been reported neither from strata bearing Ediacaran megafossils (= Redkino "Horizon" of the Valdai "Series') nor from Cambrian strata.

Phycodes pedum Zone

This zone characterizes the lower part of member 2 of the Chapel Island Formation (2.4-133 m above the base). The zonal assemblage is composed of thirteen ichnospecies (Figure 39) including complex feeding burrows (*Phycodes pedum*), vertical dwelling burrows (*Skolithos annulatus*, *Arenicolites* sp.), the vertical, helical burrow *Gyrolithes*, and anemone burrows (*Bergaueria*, *Conichnus*). Most of the new ichnospecies first appear in the basal 3 m of the zone. The restriction of *Skolithos* and *Arenicolites* to Cambrian and younger strata is controversial (compare Alpert, 1977; Cloud and Glaessner, 1982; Crimes, 1977) because all reported occurrences of Precambrian vertical burrows are questionable either because of age (e.g. no definitive Precambrian fossils present) or identification (e.g. only a horizontal view present, and thus could equally well represent an undulose horizontal burrow such as *Planolites montanus*). No ichnospecies are restricted to the *P. pedum* Zone, but the Zone can be readily recognized as that interval between the lowest occurrence of *Phycodes pedum* (approximately equivalent to the top of the *H. podolica* Zone) and the base of the *Rusophycus avalonensis* Zone.

The *Phycodes pedum* zone is equivalent to Crimes (1987) Ichnofossil Zone II. Its widespread occurrence (Figure 41), stratigraphic position above definitive Precambrian-type ichnofossils, and associated readily recognizable Cambrian-type ichnofossils enhance its correlation potential and make it an ideal zone for recognition of the basal Cambrian. The *Phycodes pedum* Zone approximately corresponds with the Rovno "Horizon" (basal Baltic "Series') of the East European Platform, a view supported by the abundance of the small organic-walled fossil *Sabellidites cambriensis* in both areas (Sokolov and Fedonkin, 1984; Fedonkin, 1985). Data from Fedonkin (this Bulletin) also imply that it is approximately equivalent to the type Nemakit Daldyn (which also has *Sabellidites cambriensis*; see Khomentovsky, 1986).

Rusophycus avalonensis Zone

This zone characterizes the remainder of the Chapel Island Formation and the overlying Random Formation. It is a concurrent range zone; its base is defined by the first appearance of *Rusophycus avalonensis*, *Taphrhelminthopsis circularis* and several other taxa (Figure 39, and its top is placed at the first local appearance of trilobites. The zonal assemblage contains at least 40 ichnospecies, most of which first appear in the zone. The new forms include arthropod burrows (*Rusophycus*, *Cruziana*), speiten dwelling burrows (*Diplocraterion*), complex feeding burrows (*Taphrhelminthopsis*, *Nereites*) and graphoglyptids (*Protopaleodictyon*, *Helminthoida*). Most of the new forms range into younger (trilobite-bearing) strata, but *Rusophycus avalonensis* and *Taphrhelminthopsis circularis* apparently are restricted to the *R. avalonensis* zone.

The *Rusophycus avalonensis* Zone is equivalent to Crimes' (1987) Ichnofossil Zone III, his highest sub-trilobite ichnofossil zone. *R. avalonensis* occurs in Newfoundland, Spain, California and northwestern Canada, and other ichnofossils indicative of this zone occur widely (Figure 41). The precise correlation of this ichnofossil zone with the Lower Cambrian shelly fossil stages remains uncertain. Nowlan *et al.* (1983) observed *R. avalonensis* in association with an *Anabarites-Protohertzina* shelly fossil assemblage that they correlated with the Nemakit Daldyn. In contrast, Crimes (1987) regarded the base of this zone as late Tommotian in age. The occurrence of *Rusophycus avalonensis* 450 m below the lowest Tommotian small shelly fossils in Newfoundland (Narbonne *et al.*, 1987) and within the type Tommotian of Siberia (Fedonkin, this publication) implies that the base of the *R. avalonensis* zone is at least as old as mid-Tommotian in these areas, and is apparently significantly older on the basis of small shelly fossils (see Landing and Benus, this Bulletin).

Diachroneity and environmental control

The three trace fossil zones are defined on the basis of benthic invertebrates, and, thus, some diachroneity should be ex-

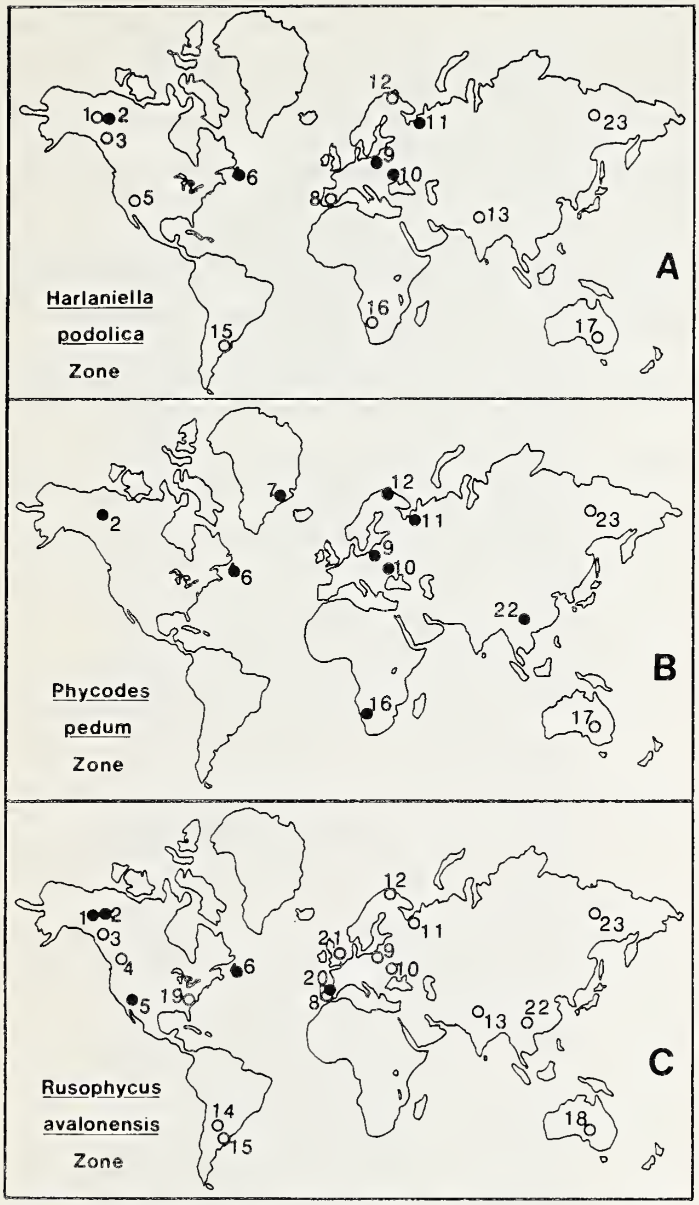


Figure 40. Global trace fossil occurrences in the Precambrian-Cambrian transition. Dark dots indicate presence of the type zonal species, light dots refer to other indicator species or assemblages of the zone. Data are from the following sources: 1 – Wernecke Mountains (Nowlan *et al.*, 1985; Narbonne and Hofmann, 1987), 2 – Mackenzie Mountains (Fritz, 1980; Hofmann, 1981; Fritz *et al.*, 1983; Aitken, 1987), 3 – Cassiar Mountains (Fritz and Crimes, 1983), 4 – southern Rocky Mountains (Young, 19772) 5 – White-Inyo Mountains (Alpert, 1977), 6 – eastern Newfoundland (Crimes and Anderson, 1985; Narbonne *et al.*, 1987), 7 – eastern Greenland (Cowie and Spencer, 1970, 8 – southern and central Spain (Brasier *et al.*, 1979; Fedonkin *et al.*, 1983; Linan, 1984), 9 – Poland (Fedonkin 1977; Paczesna, 1985, 1986), 10 – Podolia (Palij, 1976; Palij *et al.*, 1979; Fedonkin 1983; Fedonkin 1985), 11 – White Sea and eastern Baltic (Fedonkin, 1976, 1977, 1980, 1981, 1985; Palij *et al.*, 1978), 12 – Finnmark (Banks, 1970, 1973), 13 – northwestern India (Raina *et al.*, 1983; Shah and Sudan, 1983; Kumar *et al.*, 1983; Singh and Rai, 1983), 14 – northwestern Argentina (Acenolaza and Durand, 1973; Acenolaza, 1978) 15 – southeastern Argentina (Regalia and Herrera, 1981; Poire *et al.*, 1984), 16 – Namibia (Germs, 1972; Crimes and Germs, 1982), 17 – New South Wales, Australia (Webby, 1970), 18 – South Australia (Glaessner, 1969; Daily, 1972, 1973), 19 – Virginia (Simpson and Sundberg, 1987), 20 – northern Spain (Crimes *et al.*, 1987), 21 – central England (Brasier *et al.*, 1978), 22 – Meishucun (Jiang *et al.*, 1982; Crimes and Jiang, 1986), 23 eastern Siberia (Fedonkin, this Bulletin), 24 – Amadeus and Georgina Basins, Central Australia (Glaessner, 1969; Daily, 1972; M.R. Walter, personal commun., 1987)

pected (as it would be with small shelly fossils and other benthic forms). However, the diachroneity is less than can be measured by any present method. The succession of three trace fossil zones between the top of the Ediacaran assemblage (s.s.) and the lowest trilobites is presently the most detailed biostratigraphic zonations in this interval.

The three zones occur in the same sequence in sections throughout the world (Crimes, 1987; Narbonne *et al.*, 1987, Figure 7). The distribution of trace fossils in the Burin sections suggests that environmental factors, although significant, were only a second order control in the appearance of ichnospecies in the section (Narbonne *et al.*, 1987, p. 1286-1288). This is confirmed by the fact that the same succession of trace fossil assemblages occurs in an overall deepening succession in the Chapel Island Formation of the Burin Peninsula and in an overall shoaling succession in Map-unit 12 of the Mackenzie Mountains (see Aitken, 1987).

ACKNOWLEDGMENTS

Fieldwork in eastern Newfoundland was carried out with P. Myrow, E. Landing and M. Anderson. C. Luce drafted the diagrams, and A. MacDonald and K. Keicher typed the manuscript. Funding from the Natural Sciences and Engineering Research Council (N.S.E.R.C. Grant A2648) and the Canadian National Committee of the International Geeological Correlation Programme (I.G.C.P. Project 29) is gratefully acknowledged. H. Hofmann and R. Pickerill reviewed the manuscript.

REFERENCES CITED

Acenolaza, F.G. 1978. El Paleozoica inferior de Argentino según sus trazas fósiles. Ameghiniana 15:15-64.

__________ and Durand, F. 1973. Trazas fósiles del basamento cristalino del noroeste Argentino. Bul. Asoc. Geol. Cordoba 2:45-55.

Aitken, J.D. 1987. Uppermost Proterozoic formations in central Mackenzie Mountains, N.W.T. Geol. Surv. Canada Bull. 368, in press.

Alpert, S.P. 1977. Trace fossils and the basal Cambrian boundary. *In* Trace Fossils 2. *Edited by* T.P. Crimes and J.C. Harper. Geol. J., Spec. Issue 9:1-8

Banks, N.L. 1970. Trace fossils from the Late Precambrian and Lower Cambrian of Finnmark, Norway. *In* Trace Fossils. *Edited by* T.P. Crimes and J.C. Harper. Geol. J., Spec. Issue 3:19-34.

__________. 1973. Trace fossils in the Halkkavarre section of the Dividal Group (? late Precambrian-Lower Cambrian), Finnmark. Norges Geol. Unders. 288:1-6.

Brasier, M.D. 1979. The Cambrian radiation event. *In* The Origin of Major Invertebrate Groups. *Edited by* M.R. House. The Systematics Association, Spec. Vol. 12, Academic Press, New York, pp. 103-159.

__________, Hewitt, R.A. and Brasier, C.J. 1978. On the late Precambrian – Early Cambrian Hartshill Formation of Warwickshire. Geol. Mag. 115:21-36.

__________, Perejon, A. and San Jose, M.A. 1979. Discovery of an important fossiliferous Precambrian-Cambrian sequence in Spain. Estud. geol., Inst. Invest. geol. Lucas Mallada 35:379-383.

Byers, C.W. 1982. Marine biogenic sedimentary structures. *In* Animal-Sediment Relations. *Edited by* P.L. McCall and M.J.S. Trevesz. Plenum Press, New York, pp. 221-256.

Cloud, P.E. and Glaessner, M.F. 1982. The Ediacarian Period and System: Metazoa inherit the Earth. Sci. 217:783-792.

Cowie, J.W. 1971. Lower Cambrian faunal provinces. *In* Faunal Provinces in Space and Time. *Edited by* F.A. Middlemiss, P.F. Rawson, and G. Newall. Geol. J., Spec. Issue 4::31-45.

__________ 1985. Continuing work on the Precambrian-Cambrian boundary. Episodes 8:93-98.

__________ and Rozanov, A. Yu. 1974. I.U.G.S. Precambrian/Cambrian Boundary Working Group in Siberia, 1973. Geol. Mag. 111:237-252.

__________ and Spencer, A.M. 1970. Trace fossils from the Late Precambrian-Lower Cambrian of East Greenland. *In* Trace Fossils. *Edited by* T.P. Crimes and J.C. Harper. Geol. J., Spec. Issue 3:91-100.

Crimes, T. P. 1987. Trace fossils and correlation of late Precambrian and Early Cambrian strata. Geol. Mag. 124:97119.

__________ and Anderson, M.M. 1985. Trace fossils from late Precambrian-Early Cambrian strata of southeastern Newfoundland (Canada): Temporal and environmental implications. J. Paleo. 59:310-343.

__________ and Germs, G.J.B. 1982. Trace fossils from the Nama Group (Precambrian-Cambrian) of southwest Africa (Namibia). J. Paleo. 56:890-907.

__________ and Jiang, Z. 1986. Trace fossils from the PrecambrianCambrian boundary candidate at Meishucun, Jinning, Yunnan, China. Geol. Mag. 123:641-649.

__________, Legg, I. Marcos, A. and Arboleya, M. 1977. ?Late Precambrian-low Lower Cambrian trace fossils from Spain. *In* Trace Fossils 2. *Edited by* T.P. Crimes and J.C. Harper. Geol. J., spec. Issue 9:91-138.

Daily, B. 1972. The base of the Cambrian and the first Cambrian faunas. Centre for Precambrian Research, Univ. Adelaide, South Australia. Spec. Pap. 1:13-37.

__________ 1973. Discovery and significance of basal Cambrian Uratanna Formation, Mt. Scott Range, Flinders Ranges, South Australia. Search 4:202-205.

Fedonkin, M.A. 1976. Traces of multicelluar animals from the Valdai Series. Izv. Akad. Nauka S.S.S.R. 4:129-132 (in Russian).

__________ 1977. Precambrian-Cambrian ichnocoenoses of the East European Platform. *In* Trace Fossils 2. *Edited by* T.P. Crimes and J.C. Harper. Geol. J., Spec. Issue 9:183-194.

__________ 1980. Fossil traces of Precambrian metazoa. Izv. Aknd. Nauka S.S.S.R., Ser. geol. 1:39-46 (in Russian).

__________ 1981. White sea biota of the Vendian. Trudy Geol. Inst. Akad. Nauka S.S.S.R. 342, 99 pp. (in Russian).

__________ 1983. Nonskeletal fauna of the Podolian Pridnyestrov ya. *In* The Vendian of the Ukraine. *Edited by* V.A. Velikanov *et al.* Naukova Dumka, Kiev, pp. 128-139 (in Russian).

__________ 1985. Paleoichnology of Vendian metazoa. *In* The Vendian System: Historic-Geological and Paleontological Basis. *Edited by* B.S. Sokolov and M.A. Ivanovskiy. Izd. Nauka, Moscow, 1:112-116 (in Russian).

__________, Linan, E. and Perejon, A. 1983. Icnófosiles de las rocas precambrico-cambricas de la Sierra de Cordoba, Espana. Bol. Roy. Soc. Espanola Hist. Nat. (Geol.) 81:125-138.

Fritz, W.H. 1980. International Precambrian-Cambrian Boundary Working Group's 1979 field study to Mackenzie Mountains, Northwest Territories, Canada. Geol. Surv. Canada, Pap. 801A:41-45.

__________ and Crimes, T.P. 1985. Lithology, trace fossils and correlation of Precambrian-Cambrian boundary beds, Cassiar Mountains, north-central British Columbia, Canada. Geol. Surv. Canada, Pap. 83-13, 24 pp.

__________, Narbonne, G.M., and Gordey, S.P. 1983. Strata and trace fossils near the Precambrian-Cambrian boundary, Mackenzie, Selwyn and Wernecke Mountains, Yukon and Northwest Territories. Geol. Surv. Canada, Pap. 83-18:365-375.

Germs, G.J.B. 1972. Trace fossils from the Nama Group, southwest Africa. J. Paleo. 46:864-870.

Glaessner, M.F. 1969. Trace fossils from the Precambrian and basal Cambrian. Lethaia 2:369-393.

Hoffman, H.J. 1981. First record of a Late Proterozoic faunal assemblage in the North American Cordillera. Lethaia 14:303-310.

Jiang, Z. 1984. Global distribution of the earliest shelly metazoans. Geol. Mag. 121:185-188.

__________, Luo, H. and Zang, S. 1982. Trace fossils of the Meischucun section in China. Geol. Rev. 28:7-13.

Khomentovsky, V.V. 1986. The Vendian System of Siberia and a standard stratigraphic scale. Geol. Mag. 123:333-348.

Kumar, G., Raina, B.K., Bhatt, D.K. and Jangpangi, B.S. 1983. Lower Cambrian body and trace fossils from the Tal Formation, Garhwal synform, Uttar Pradesh, India. J. Paleo. Soc. India 28:106-111.

Linan, E. 1984. Los ichnófosiles de la formacion Torrearboles (? Precambrico-Cambrico Inferior) en los alrededores de fuente de Cantos, Badajoz. Cuad. Lab. Geol. Laxe 8:47-74.

Narbonne, G.M. and Hoffman, H.J. 1987. Ediacaran biota of the Wernecke Mountains, Yukon, Canada. Palaeo. 30 (in press).

__________, Myrow, P., Landing, E., and Anderson, M.M. 1987. A candidate stratotype for the Precambrian-Cambrian boundary, Fortune Head, Burin Peninsula, southeastern Newfoundland. Canadian J. of Earth Sciences 24:1277-1293.

Nowlan, G.S., Narbonne, G.M. and Fritz, W.H. 1985. Small shelly fossils and trace fossils near the Precambrian-Cambrian boundary in the Yukon Territory, Canada. Lethaia 18:233-256.

Paczesna, J. 1985. Upper Vendian and Lower Cambrian trace fossils of southern Lublin Region. Kwart. Geol. 29:255-270 (in Polish with English summary).

__________ 1986. Upper Vendian and Lower Cambrian ichnocoenoses of Lublin region. Biul. Inst. Geologicznego 355:31-47.

Palij, V.M. 1976. Remains of soft-bodied animals and trace fossils from the Upper Precambrian and Lower Cambrian of Podolia. *In* Paleontologiya i stratigrafiya verkhnego dokembriya i nizhenego kembriya yugozapada VostochnoEvropeiskoi platformy, pp. 63-76. Naukova dumka, Kiev (in Russian).

__________, Posti, E. and Fedonkin, M.A. 1979. Soft-bodied Metazoa and animal trace fossils in the Vendian and Early Cambrian. *In* Upper Precambrian and Cambrian Paleontology of the East European Platform. *Edited by* A. Urbanek and A. Yu Rozanov. Publishing House Wydawnictwa pp. 49-82. Moscow: Nauka. Geologiczne, Warsaw, pp. 56-93 (in Russian).

Poire, D.G., Del Valle, A., and Regalia, G.M. 1984. Trazas fósiles en Cuarcitas de la Formacion Sierras Baya (Precambrico) y su comparicion con las de la Formacion Balarce (Cambro-Ordovicico), Sierras septentrionales de la Provincia de Buenos Aires, Noveno congreso Geologie Argentino S.C. de Bariloche, 1984. Actas 4:249-266.

Raina, B.K., Kumar, G., Bhargava, O.N. and Sharma, V.P. 1983. ?Precambrian low Lower Cambrian ichnofossils from the Lolab Valley, Kashmir Himalyaya, India. J. Palaeo. Soc. India 28:91-94.

Regalia, G.M. and Herrera, H.H. 1981. *Phycodes* aff. *pedum* (traza fósil) en estratos cuarciticos de San Manuel, Sierras Septentrionales de la Province de Buenos Aires, Republica Argentina. Rev. Asoc. Geol. Argentina 36:257-261.

Rozanov, A. Yu. 1984. The Precambrian-Cambrian boundary in Siberia. Episodes 7:20-24.

Seilacher, A. 1956. Der Beginn des Kambriums als biologische Wende. Neues Jahrb. Geol. Paläont. Abh. 103:155-180.

Shah, S.K., and Sudan, C.S. 1983. Trace fossils from the Cambrian of Kashmir and their stratigraphic significance. J. Geol. Soc. India 24:194-202.

Simpson, E.L., and Sundberg, F.A. 19877. Early Cambrian age for synrift deposits of the Chilhowee Group of southwestern Virginia. Geol. 15:123-126.

Singh, I.B., and Rai, V. 1983. Fauna and biogenic structures in Krol-Tal succession (Vendian-Early Cambrian). Lesser Himalaya: their biostratigraphic and palaeoecological significance. J. Palaeo. Soc. India 28:67-90.

Sokolov, B.S., and Fedonkin, M.A. 1984. The Vendian as the terminal System of the Precambrian. Episodes 7:12-19.

Stanley, S.M. 1976. Fossil data and the Precambrian-Cambrian evolutionary transition. Amer. J. Sci. 276:56-76.

Webby, B.D. 1970. Late Precambrian trace fossils from New South Wales. Lethaia 3:79-109.

Young, F.G. 1972. Early Cambrian and older trace fossils from the southern Cordillera of Canada. Canadian J. Earth Sci. 9:1-17.

APPENDIX

Bibliography of George Frederick Matthew

Ed Landing[1] **and Randall F. Miller**[2]

[1] New York State Geological Survey, The State Education Department
[2] New Brunswick Museum, Saint John

Bailey, L.W. and Matthew, G.F. 1864. Geological Map of the Counties of St. John, Kings, Queens, and Albert, New Brunswick. T.W. Strong, New York.

Bailey, L.W. and Matthew, G.F. 1870. Remarks on the age and relationships of the metamorphic rocks of New Brunswick and Maine. Assoc. Advance. Sci., Proc. 18:179-195.

Bailey, L.W. and Matthew, G.F. 1872. Preliminary report on the geology of southern New Brunswick. Geol. Surv. Canada Rept. Prog., Pt. 2, 1870-71:13-240.

Bailey, L.W. and Matthew, G.F. 1876. Summary report of geological observations in New Brunswick. Geol. Surv. Canada Rept. Prog., 1874-75, Pt. 5:84-89.

Bailey, L.W. and Matthew, G.F. 1919 (1918). Some problems of New Brunswick geology. Tran. Roy. Soc. Canada, 3rd series 12(4):105-130.

Bailey, L.W., Matthew, G.F., and Ells, R.W. 1873. Report of observations on the Carboniferous System of New Brunswick in the counties of Queens, Sunbury and a potion of York. Geol. Surv. Canada Rept. Prog., 1872-73, Pt. 8:180-230.

Bailey, L.W., Matthew, G.F. and Ells, R.W. 1877. Report of geological observations in southern New Brunswick. Geol. Surv. Canada Rept. Program 1, 16:348-368.

Bailey, L.W., Matthew, G.F. and Ells, R.W. 1880. Report on the geology of southern New Brunswick, Embracing the counties of Charlotte, Sunbury, Queens, Kings, St. John, and Albert. Geol. Surv. Canada Rept. Prog., 1878-79, pt. D:1-26.

Matthew, G.F. 1863. Observations on the geology of St. John County, New Brunswick. Canadian Nat. Geol. 8:241-259.

Matthew, G.F. 1865. On the Azoic and Palaeozoic rocks of southern New Brunswick. Quar. J. Geol. Soc. London 21:422 434.

Matthew, G.F. 1865. Cupiferous rocks of southeastern New Brunswick, pp. 149-151. Notes on the geology of Charlottte county, pp. 153-157, Dunsinane coal, pp. 157-158. *In* L.W. Bailey, Observations on the geology of southern New Brunswick, made principally during the summer of 1864 by Professor L.W. Bailey, Messrs. Geo. F. Matthew and C.F. Hartt. House of Assembly, Fredericton.

Matthew, G.F. 1868. On the Azoic and Palaeozoic rocks of southern New Brunswick. Canadian Nat. Geol. 3:3878-391.

Matthew, G.F. 1869. On the occurrence of arctic and western plants in continental Acadia. Canadian Nat. 4:139-166.

Matthew, G.F. 1872. On the surface geology of New Brunswick. Canadian Nat. 6:89-107.

Matthew, G.F. 1874. Note sur les mollusques de la formation post-Pliocene de l'Acadie (traduction du manuscript anglais par Armand Thielens). Soc. roy. Malacologique de Belgique, Ann. 9:35-50.

Matthew, G.F. 1875. Impressions of Cuba. Canadian Nat. 7:19-34, 75-85.

Matthew, G.F. 1875. On the surface geology of New Brunswick. Canadian Nat. 7:433-454.

Matthew, G.F. 1878. On the Mollusca of the post-Pliocene formation in Acadia. Canadian Nat. 8:104-117.

Matthew, G.F. 1878. Report of the slate formations of the northern part of Charlotte County, New Brunswick, with a summary of geological observations in the southeastern part of the same county. Geol. Surv. Canada Rept. Prog., 1876-77:321-350.

Matthew, G.F. 1879. Report on the Upper Silurian and Kingston (Huronian) of southern New Brunswick, 1877. Geol. Surv. Canada Rept. Prog., 1877-8, pt. E:1-6.

Matthew, G.F. 1879. Report on the superficial geology of southern New Brunswick. Geol. Surv. Canada Rept. Prog., 1877-78, pt. EE:1-36.

Matthew, G.F. 1881. Tidal erosion in the Bay of Fundy. Canadian Nat. 9:368-373.

Matthew, G.F. 1883 (1882). Illustrations of the fauna of the St. John Group. No. 1. The *Paradoxides*. Tran. Roy. Soc. Canada 1(4):87-108.

Matthew, G.F. 1883. On a method of distinguishing lacustrine from marine deposits. Tran. Roy. Soc. Canada 1(4):147-149.

Matthew, G.F. 1883. Illustrations of the fauna of the St. John Group. No. 1. The *Paradoxides*. Tran. Roy. Soc. Canada 1(4):271-279.

Matthew, G.F. 1883. Lacustrine formation of Torryburn Valley. Bull. Nat. HIst. Soc. New Brunswick 2:3-20.

Matthew, G.F. 1883. A supposed specimen of aboriginal art. Ann. Rept. Smithsonian Inst. for 1881, p. 672.

Matthew, G.F. 1884. Discoveries at a village of the Stone Age at Bocabec, N.B. Bull. Nat. Hist. Soc. New Brunswick 3:6-29.

Matthew, G.F. 1884. The geological age of the Acadian fauna. Geol. Mag. 1:470-471.

Matthew, G.F. 1884. The primitive conocoryphean. Geol. Mag. 1:471-472.

Matthew, G.F. 1884. Illustrations of the fauna of the St. John Group. Sci. 3:676.

Matthew, G.F. 1885 (1884). Illustrations of the fauna of the St. John Group continued: On the Conocoryphea, with further remarks on *Paradoxides*. Tran. Roy. Soc. Canada 2(4):9 124.

Matthew, G.F. 1885. An outline of recent discoveries in the Saint John Group. Bull. Nat. Hist. Soc. New Brunswick 4:97-102.

Matthew, G.F. 1885. Recent discoveries in the Saint John Group. Canadian Rec. Sci. 1:136-141.

Matthew, G.F. 1885. A new genus of Cambrian pteropods. Canadian Rec. Sci. 1:149-152.

Matthew, G.F. 1885. Note on the genus *Stenotheca*. Geol. Mag. 2:425-426.

Matthew, G.F. 1885. On the probable occurrence of the great Welsh *Paradoxides*, *P. davidus*, in America. Amer. J. Sci. 30:72-73.

Matthew, G.F. 1885. Notice of a new genus of pteropods from the St. John Group. Amer. J. Sci. 30:293-294.

Matthew, G.F. 1885. The geological age of the Acadian fauna. Brit. Assoc. Advance. Sci. Rept. 54:742-743.

Matthew, G.F. The primitive concoryphean. Brit. Assoc. Advance. Sci. Rept. 54:743-44.

Matthew, G.F. 1886 (1885). Illustrations of the fauna of the St. John Group continued. No. 3. Descriptions of new genera and species, (including a description of a new species of *Solenopleura* by J.F. Whiteaves). Tran. Roy. Soc. Canada 3(4):29-84.

Matthew, G.F. 1886. Synopsis of the fauna in Division 1 of the St. John Group, with preliminary notes on the higher faunas of the same group. Bull. Nat. Hist. Soc. New Brunswick 5: 25-31.

Matthew, G.F. 1886. Pteropoda of the St. John Group. Amer. J. Sci. 31:72.

Matthew, G.F. 1886. Note on the occurrence of *Olenellus*? *kierulfi* in America. Amer. J. Sci. 31:472-473.

Matthew, G.F. 1887 (1886). On the Cambrian faunas of Cape Breton and Newfoundland. Tran. Roy. Soc. Canada 4(4):147-157.

Matthew, G.F. 1887. A preliminary notice of a new genus of Silurian fishes. Bull. Nat. Hist. Soc. New Brunswick, No. 6:69-73.

Matthew, G.F. 1887. Structural features of *Discina acadica* of the St. John Group. Canadian Rec. Sci. 2:9-11.

Matthew, G.F. 1887. Discovery of a pteraspidian fish in the Siluran rocks of New Brunswick. Canadian Rec. Sci. 2:251 252.

Matthew, G.F. 1887. Abstract of paper on the Cambrian faunas. Canadian Rec. Sci. 2:255-258.

Matthew, G.F. 1887. Additional note on the pteraspidian fish of the Siluran rocks. Canadian Rec. Sci. 2:323-326.

Matthew, G.F. 1887. Illustrations of the fauna of the St. John Group; No. 4, On the smaller-eyed trilobites of Division 1, with a few remarks on the species of the higher divisions of the group. Canadian Rec. Sci. 2:357-363.

Matthew, G.F. 1887. Illustation of the fauna of the St. John Group; No.5, On the great Acadian trilobite, *Paradoxides regina*. Canadian Rec. Sci. 2:434.

Matthew, G.F. 1887. The great Acadian *Paradoxides*. Amer. J. Sci. 33:388-390.

Matthew, G.F. 1887. On the kin of *Paradoxides* (*Olenellus*?) *kierulfi*. Amer. J. Sci. 33:390-392.

Matthew, G.F. 1887. Minerals of New Brunswick. Board of Education Report, Fredericton. 14p.

Matthew, G.F. 1888(1887). Illustations of the fauna of the St. John Group. No. 4-Part 1. Description of a new genus of *Paradoxides regina*). Part II. The smaller trilobites with eyes (Ptychoparidae and Ellipsocephalidae). Tran. Roy. Soc. Canada 5(4):155-166.

Matthew, G.F. 1888. On *Psammichnites* and the early trilobites of the Cambrian rocks in eastern Canada. Amer. Geol. 2:1-9.

Matthew, G.F. 18889 (1888). On some remarkable organisms of the Silurian and Devonian rocks in southern New Brunswick. Tran. Roy. Soc. Canada 6(4):49-62.

Matthew, G.F. 1889. On a basal series of Cambrian rocks in Acadia. Canadian Rec. Sci. 3:21-29.

Matthew, G.F. 1889. On the classification of the Cambrian rocks in Acadia. Canadian Rec. Sci. 3:71-81.

Matthew, G.F. 1889. On some remarkable organisms of the Silurian and Devonian rocks in southern New Brunswick. Canadian Rec. Sci. 3:161-162.

Matthew, G.F. 1889. On the classification of Cambrian rocks in Acadia No. 2. Canadian Rec. Sci. 3:303-315.

Matthew, G.F. 1889. Supplementary note to "Classification of the Cambrian rocks in Acadia." Canadian Rec. Sci. 3:371-372.

Matthew, G.F. 1889. On the Cambrian organisms in Acadia. Canadian Rec. Sci. 3:383-387.

Matthew, G.F. 1889. How is the Cambrian divided? A plea for the classification of Salter and Hicks. Canadian Rec. Sci. 3:475-485.

Matthew, G.F. 1889. On the occurrence of *Leptoplastus* in the Acadian Cambrian rocks. Canadian Rec. Sci. 3:485-489.

Matthew, G.F. 1889. Second note on *Stenotheca*. Geol. Mag. 6:210-211.

Matthew, G.F. 1889. How is the Cambrian divided? A plea for the classification of Salter and Hicks. Amer. Geol. 4:139-148.

Matthew, G.F. 1889. Sur le developpement des premiers trilobites. Soc. roy. Malacologique de Belgique, Ann. 23:351-362.

Matthew, G.F. 1890 (1889). On Cambrian organisms in Acadia. Tran. Roy. Soc. Canada 7(4):135-162.

Matthew, G.F. 1890. Tracks of organic origin in rocks of the Animike Group. Amer. J. Sci., 3rd ser., 39:145-147.

Matthew, G.F. 1890-91. Charles Frederick Hartt. Bull. Nat. Hist. Soc. New Brunswick, No. 9; 1-24.

Matthew, G.F. 1890-91. President's annual address. 1. Introduction. 2. On the Palaeozoic insects. 3. On the existence of organisms in the pre-Cambrian rocks. Bull. Nat. Hist. Soc. New Brunswick 9:25-35.

Matthew, G.F. 1890-91. *Eozoon* and other low organisms in Laurentian rocks at St. John. Bull. Nat. Hist. Soc. New Brunswick 9:36-41, 67.

Matthew, G.F. 1890-91. On the occurrence of sponges in Laurentian rocks at St. John, N.B. Bull. Nat. Hist. Soc. New Brunswick 9:42-45.

Matthew, G.F. 1891 (1890). Illustrations of the fauna of the St. John Group. No. 5. Tran. Roy. Soc. Canada 8(4):123-166.

Matthew, G.F. 1891. Charles Frederick Hartt. Canadian Rec. Sci., 4:111-130.

Matthew, G.F. 1891. On some causes which may have influenced the spread of the Cambrian fauna. Canadian Rec. Sci. 4:255-269.

Matthew, G.F. 1891. On a new horizon in the St. John Group. Canadian Rec. Sci. 4:339-343.

Matthew, G.F. 1891. Note on *Leptoplastus*. Canadian REc. Sci. 4: 461-462.

Matthew, G.F. 1891. Fish remains in the Lower Helderberg of New Brunswick. "Letter regarding age of Silurian fish (*Diplaspis acadica*)." Amer. Geol. 8:61-62.

Matthew, G.F. 1891. Notes on Cambrian faunas. I. The Taconic fauna of Emmons compared with the Cambrian horizons of the St. John Group. Amer. Geol. 8:287-291.

Matthew, G.F. 1892 (1891). Illustrations of the fauna of the St. John Group. No. 6. Tran. Roy. Soc. Canada. 9(4):33-65.

Matthew, G.F. 1892. Discoveries at a village of the Stone Age at Bocabec, N.B. Bull. Nat. Hist. Soc. New Brunswick.

Matthew, G.F. 1892 *Protolenus* – A new genus of Cambrian trilobite. Bull. Nat. Hist. Soc. New Brunswick 10:5-29.

Matthew, G.F. 1892. List of the fossils found in the Cambrian rocks in and near St. John. Bull. Nat. Hist. Soc. New Brunswick 10:xi-xxii.

Matthew, G.F. 1892. Are the Eozoonal Limestones at St. John, New Brunswick, Pre-Cambrian? Amer. Geol. 9:212-214.

Matthew, G.F. 1893 (1892). On the diffusion and sequence of the Cambrian faunas – Presidential address for the year. Tran. Roy. Soc. Canada 10(4):3-16.

Matthew, G.F. 1893 (1892). Illustrations of the fauna of the St. John Group. No. 7. Tran. Roy. Soc. Canada 10(4):95-109.

Matthew, G.F. 1893. The climate of Acadia in the earliest times. Bull. Nat. Hist. Soc. New Brunswick, No. 11:3-18.

Matthew, G.F. 1893. Notes on Cambrian faunas – development of the fauna of band B in the Acadian division (Div. 1) of the St. John Group. Canadian Rec. Sci. 5:247-258.

Matthew, G.F. 1893. *Trematobolus*, an articulate brachiopod of the inarticulate order. Canadian Rec. Sci. 5:276-279.

Matthew, G.F. 1893. Is the fauna called "Primordial" the most ancient fauna? Canadian Rec. Sci. 5:347-350.

Matthew, G.F. 1893. On some new discoveries in the Cambrian beds of Sweden. Canadian Rec. Sci. 5:350-351.

Matthew, G.F. 1893. Review of "Swedish Cambrian-Silurian Hyolithidae and Conulariidae, by G. Holm." Canadian Rec. Sci. 5:433-440.

Matthew, G.F. 1893. The St. John Group. Amer. Geol. 12:340-341.

Matthew, G.F. 1894(1893). Illustrations of the fauna of the St. John Group. No. 8. Tran. Roy. Soc. Canada 11(4): 85 129.

Matthew, G.F. 1894. Movements of the Earth's crust at St. John, N.B., in Post-Glacial times. Bull. Nat. Hist. Soc. New Brunswick 12:34-42.Matthew, G.F. 1894. The outlets of the St. John River. Bull. Nat. Hist. Soc. New Brunswick 12:43-62.

Matthew, G.F. 1894. Organic remains of the Little River Group. Amer. Geol. 14:67.

Matthew, G.F. 1894. Post-glacial faults at St. John's, N.B. Amer. J. Sci. 48:501-503.

Matthew, G.F. 1895 (1894). On the organic remains of the Little River Group, No. 11. Tran. Roy. Soc. Canada 12(4):89-100.

Matthew, G.F. 1895(1894). On the organic remains of the Little River Group, No. III. Tran. Roy. Soc. Canada 12(4):101-111.

Matthew, G.F. 1895. Traces of the Ordovician System on the Atlantic Coast. Tran. Roy. Soc. Canada, 2nd Ser., 1(4): 253-271.

Matthew, G.F. 1895. Organic remains of the Little River Group, No. IV. Tran. Roy. Soc. Canada, 2nd series, 1(4):273-279.

Matthew, G.F. 1895. The *Protolenus* fauna. Tran. New York Acad. Sci. 14:101-153.

Matthew, G.F. 1895. Two new Cambrian graptolites with notes on other species of Graptolitidae of that age. Tran. New York Acad. Sci. 14:262-273.

Matthew, G.F. 1895. Early Protozoa. Amer. Geol. 15:146-153.

Matthew, G.F. 1895. The *Protolenus* fauna. Sci. (new ser.) 1:452-453.

Matthew, G.F. 1896. Report on the summer camp at French Lake. Bull. Nat. Hist. Soc. New Brunswick 13:84-88.

Matthew, G.F. 1896. Report on the summer camp at Lepreau Basin. Bull. Nat. Hist. Soc. New Brunswick 13:88-93.

Matthew, G.F. 1896. Report on Geology. Bull. Nat. Hist. Soc. New Brunswick 13:94-95.

Matthew, G.F. 1896. The Cambrian terrain at Tejrovie, Bohemia. Canadian Rec. Sci. 6:46-48.

Matthew, G.F. 1896 (1894). Ancient myriapods. Canadian Rec. Sci. 6:93-99.

Matthew, G.F. 1896. On the occurrence of cirripedes in the Cambrian rocks of North America. Tran. New York Acad. Sci. 15:144-146.

Matthew, G.F. 1896. Faunas of the *Paradoxides* beds in eastern North America, No. 1. Tran. New York Acad. Sci. 15:192-247.

Matthew, C.F. 1896. Notes on Cambrian faunas; the genus *Microdiscus*. Amer. Geol. 18:28-31.

Matthew, G.F., 1896. Some features of Early Cambrian faunas. Brit. Assoc. Advance. Sci. Rept. 66:785-87.

Matthew, G.F. 1897. Studies on Cambrian faunas. Tran. Roy. Soc. Canada, 2nd Ser., 3(4):165-211.

Matthew, G.F. 1897. Abraham Gesner. A review of his scientific work. Bull. Nat. Hist. Soc. New Brunswick 15:3-48.

Matthew, G.F. 1897. Description of an extinct Palaeozoic insect, and a review of the fauna with which it occurs. Bull. Nat. Hist. Soc. New Brunswick 15:49-60.

Matthew, G.F. 1897. The oldest *Siphonotreta*. Geol. Mag. 4:68-71.

Matthew, G.F. 1897. What is the *Olenellus* fauna? Amer. Geol. 19:396-407.

Matthew, G.F. 1897. Some features of the Early Cambrian faunas. Sci. (new ser.) 5:254-256.

Matthew, G.F. 1898. Studies on Cambrian faunas, No. 2. Tran. Roy. Soc. Canada, 2nd Ser., 4(4):123-153.

Matthew, G.F. 1898. Recent discoveries in the St. John Group, No. 2. Bull. Nat. Hist. Soc. New Brunswick 16:32-43.

Matthew, G.F. 1898. Report on the geological data obtained at Quaco summer camp of 1887. Bull. Nat. Hist. Soc. New Brunswick16:67-68.

Matthew, G.f. 1898. Some characteristic genera of the Cambrian. Geol. Mag. 5:82-83.

Matthew, G.F. 1898. The oldest Paleozoic fauna. Amer. Geol. 22:262.

Matthew, G.F. 1898. The oldest Paleozoic fauna. Sci. (new ser.) 8:503-504.

Matthew, G.F. 1898. The oldest Palaeozoic fauna. Amer. Assoc. Advance. Sci. Proc. 47:301-302.

Matthew, G.F. 1898. Some characteristic genera of the Cambrian. Brit. Assoc. Advance. Sci. Rept. 67:657-568.

Matthew, G.F. 1899. Studies on Cambrian faunas, No. 3. – Upper Cambrian fauna of Mount Stephen, British Columbia. – The trilobites and worms. Tran. Roy. Soc. Canada, 2nd Ser., 5(4):39-66.

Matthew, G.F., 1899. Studies on Cambrian faunas, No. 4. – Fragments of the Cambrian faunas of Newfoundland. Tran. Roy. Soc. Canada, 2nd Ser., 5(4):67-95.

Matthew, G.F. 1899. The Etcheminian fauna of Smith Sound, Newfoundland. Tran. Roy. Soc. Canada, 2nd Ser. 5(4):97 119.

Matthew, G.F. 1899. A new Cambrian trilobite. Bull. Nat. Hist. Soc. New Brunswick 17:137-142.

Matthew, G.F. 1899. A Paleozoic terrane beneath the Cambrian. New York Acad. Sci., Ann., 12:41-56.

Matthew, G.F. 1900. Preliminary notice of the Etcheminian fauna of Newfoundland. Bull. Nat. Hist. Soc. New Brunswick 18:189-197.

Matthew, G.F. 1900. Preliminary notice of the Etcheminian fauna of Cape Breton. Bull. Nat. Hist. Soc. New Brunswick 18:198-208.

Matthew, G.F. 1900. A quarry and workshop of the Stone Age in New Brunswick. Tran. Roy. Soc. Canada, 2nd Ser., 6(2):6169.

Matthew, G.F. 1900. A forest fire at St. John about 2,000 years ago. Canadian Rec. Sci. 8:213-218.

Matthew, G.F. 1900. *Oldhamia*. Canadian Rec. Sci. 8:228-232.

Matthew, G.F. 1900. Mr. Walcott's view of the Etcheminian. Amer. Geol. 25:255-258.

Matthew, G.F. 1901. *Acrothyra* and *Hyolithes* – a comparison. Tran. Roy. Soc. Canada, 2nd Ser., 7(4):93-107.

Matthew, G.F. 1901. *Hyolithes gracilis* and related forms from the Lower Cambrian of the St. John Group. Tran. Roy. Soc. Canada, 2nd Ser., 7(4):109-111.

Matthew, G.F. 1901. A backward step in paleobotany. Tran. Roy. Soc. Canada, 2nd Ser., 7(4):113-122.

Matthew, G.F. 1901. New species of Cambrian fossils from Cape Breton. Bull. Nat. Hist. Soc. New Brunswick 19:269- 286.

Matthew, G.F. 1901. *Acrothyra*, new genus of Etcheminian brachiopods. Bull. Nat. Hist. Soc. New Brunswick 19:303304.

Matthew, G.F. 1901. The Devonian of the Acadian provinces. Canadian Rec. Sci. 8:344-345.

Matthew, G.F. 1901. Are the St. John plant beds Carboniferous? Amer. Geol. 27:383-386.

Matthew, G.F. 1901. New species of Cambrian fossils from Cape Breton. Amer. J. Sci. 11:396.

Matthew, G.F. 1901. *Monocraterion* and *Oldhamia*. Irish Nat. 10:135-136.

Matthew, G.F. 1901. Les plus anciennes faunas paleozoiques. 8th Int. Geol. Cong., Paris, pp. 313-316.

Matthew, G.F. 1902. Notes on Cambrian faunas. Tran. Roy. Soc. Canada, 2nd Ser., 8(4):93-112.

Matthew, G.F. 1902. Additional notes on the Cambrian of Cape Breton, with descriptions of new species. Bull. Nat. Hist. Soc. New Brunswick 20:377-426.

Matthew, G.F. 1902. Letter on D. White's article in the last issue. Canadian Rec. Sci. 8:344-345.

Matthew, G.F. 1902. Ostracoda of the basal Cambrian rocks in Cape Breton. Canadian Rec. Sci. 8:437-470.

Matthew, G.F. 1902. Stratigraphy vs. paleontology in Nova Scotia. Sci. (new ser.) 16:513-514.

Matthew, G.F. 1903. An attempt to classify Paleozoic batrachian footprints. Tran. Roy. Soc. Canada, 2nd Ser., 9(4):104-121.

Matthew, G.F. 1903. Note on the discovery of a small chalice of the French period at Tracadie, N.B. Bull. Nat. Hist. Soc. New Brunswick 21:1-4.

Matthew, G.F. 1903. Note in reference to batrachian footprints. Bull. Nat. Hist. Soc. New Brunswick 21:102.

Matthew, G.F. 1903. On batrachian and other footprints from the coal measures of Joggins, N.S. Bull. Nat. Hist. Soc. New Brunswick 21:103-108.

Matthew, G.F. 1903. New genera of batrachian footprints in the Carboniferous System in eastern Canada. Canadian Rec. Sci. 9:99-111.

Matthew, G.F. 1903. On batrachian and other footprints from the coal measures of Joggins, N.S. Amer. Geol. 32:34-39.

Matthew, G.F. 1903. "How long ago was North America peopled?" Amer. Geol. 32:195-196.

Matthew, G.F. 1903. Report on the Cambrian rocks of Cape Breton. (Prepared for the Geological Survey of Canada, Robert Bell). Rept. No. 797. S.E. Dawson, Ottawa. 246 pp.

Matthew, G.F. 1904. Note on Oliver's Cave. Bull. Nat. Hist. Soc. New Brunswick 22:171-174.

Matthew, G.F. 1904. Notes on Cambrian faunas, No. 9. Bull. Nat. Hist. Soc. New Brunswick 22:246.

Matthew, G.F. 1904. Note on the genus *Hylopus* of Dawson. Bull. Nat. Hist. Soc. New Brunswick 22:247-252.

Matthew, G.F. 1904. Physical aspect of the Cambrian rocks in eastern Canada with a catalogue of the organic remains found in them. Bull. Nat. Hist. Soc. New Brunswick 22:253-278.

Matthew, G.F. 1905 (1904). New species and a new genus of batrachian footprints of the Carboniferous System in eastern Canada. Tran. Roy. Soc. Canada, 2nd Ser., 10(4):77-121.

Matthew, G.F. 1905. Review of "The Cambrian *Dictyonema* fauna of the slate belt of eastern New York" by R. Ruedemann. Canadian Rec. Sci. 9:196-197.

Matthew, G.F. 1905. On Cambrian and Silurian rocks in York Co., N.B. Letter *In*, Bailey, L.W., Geol. Surv. Canada Summ. Rept., 1901, Pt.A:197-201.

Matthew, G.F. 1905. Cambrian rocks and fossils of Cape Breton. Geol. Surv. Canada Summ. Rept. 1901, Pt. A:223-232.

Matthew, G.F. 1906. A review of the flora of the Little River Group. Tran. Roy. Soc. Canada, 2nd Ser., 12(4):99-149.

Matthew, G.F. 1906. New species and a new genus of Devonian plants. Bull. Nat. Hist. Soc. New Brunswick 24:393-398.

Matthew, G.F. 1906. Notes on Cambrian faunas, No. 9 Ostracoda, No. 10 Trilobita. Bull. Nat. Hist. Soc. New Brunswick 24:406, 475-480.

Matthew, G.F. 1906. Why is the winter so mild? Bull. Nat. Hist. Soc. New Brunswick 24:484-488.

Matthew, G.F. 1906. A review of the flora of the Little River Group. Sci. (new ser.) 23:972-973.

Matthew, G.F. 1907. A new genus and a new species of Silurian fish. Tran. Roy. Soc. Canada, 3rd Ser., 1(4):7-11.

Matthew, G.F. 1907. On some new species of Silurian and Devonian plants. Tran. Roy. Soc. Canada, 3rd Ser., 1(4):185-197.

Matthew, G.F. 1907. Note on *Archaeozoon*. Bull. Nat. Hist. Soc. New Brunswick 25:547-552.

Matthew, G.F. 1908. Geological cycles in the Maritime Provinces of Canada. Tran. Roy. Soc. Canada, 3rd Ser., 2(4):121-143.

Matthew, G.F. 1908. The physical evolution of Acadia. Part 1 – The insular stage, or pre-Devonian development. Bull. Nat. Hist. Soc. New Brunswick 26:3-16.

Matthew, G.F. 1908. Brief notes on Nova Scotia geology. Geol. Mag. 5:568-569. (abstracts of six papers).

Matthew, G.F. 1909. Phosphate deposits of South Carolina and New Brunswick. Bull. Nat. Hist. Soc. New Brunswick 27:121-126.

Matthew, G.F. 1910 (1909). The Geological Age of the Little River Group. Tran. Roy., Soc. Canada, 3rd Ser., 3(4):67-75.

Matthew, G.F. 1910 (1909). Revision of the flora of the Little River Group. No.2. Tran. Roy. Soc. Canada, 3rd Ser., 3(4):77-113.

Matthew, G.F. 1910 (1909). Remarkable forms of the Little River Group. Tran. Roy. Soc. Canada, 3rd Ser., 3(4): 115-133.

__________Matthew, G.F. 1910. The oldest Silurian flora. Bull. Nat. Hist. Soc. New Brunswick 28:241-250.

Matthew, G.F. 1910. Changes of climate in the maritime provinces after the maximum of the latest glaciation. 11th Int. Geol. Cong., Stockholm, *In* Die Veranderungen des Klimas seit dem Maximum der letzten Eiszeit, pp. 377-380. Matthew, G.F. 1911 (1910). Review of the flora of the Little River Group, No. III. Tran. Roy. Soc. Canada, 3rd Ser., 4(4):3-21.

Matthew, G.F. 1911. Were there climatic zones in Devonian time? Tran. Roy. Soc. Canada, 3rd Ser., 5(4):125-153.

Matthew, G.F. 1911. Rocks and minerals of Rockwood Park. Bull. Nat. Hist. Soc. New Brunswick 29:339-341.

Matthew, G.F. 1912. Sketch of the history of The Natural History Society of New Brunswick. Bull. Nat. Hist. Soc. New Brunswick 30:457-474.

Matthew, G.F. 1912. The sudden appearance of the Cambrian fauna. 11th Int. Geol. Cong., Stockholm 1:547-559.

Matthew, G.F. 1913 (1912). A new flora in the older Paleozoic rocks of southern New Brunswick, Canada. Tran. Roy. Soc. Canada, 3rd Ser., 6(4):83-99.

Matthew, G.F. 1915 (1914). The physics of the Cambrian formation in eastern

Canada, and the peculiarities of its faunas. Tran. Roy. Soc. Canada, 3rd Ser., 8(4):69-85.

Matthew, G.F. 1917 (1916). Notes on Cambrian faunas, No. 12. Tran. Roy. Soc. Canada, 3rd Ser., 10(4):45-54.

Matthew, G.F. 1918 (1917). The Upper Devonian plants of Kiltorcan with descriptions of some new forms. Tran. Roy. Soc. Canada, 3rd Ser., 11(4):99-116.

Matthew, G.F. 1920 (1919). The delta of the Little River Group and some of its peculiarities. Tran. Roy. Soc. Canada, 3rd Ser., 13(4):17-21.

Matthew, G.F. 1921 (1920). A Devonian glacier. Tran. Roy. Soc. Canada, 3rd Ser., 14(4):1-6.

Matthew, G.F. 1921. On the Mispec Group (Devonian). Tran. Roy. Soc. Canada, 3rd Ser., 15(4):105-109.

Matthew, G.F. and Bailey, L.W. 1869. Remarks on the age and relations of the metamorphic rocks of New Brunswick and Maine. Canadian Nat. (new ser.) 4:326-328.

Matthew, G.F. and Bailey, L.W. 1869. Remarks on the age and relations of the metamorphic rocks of New Brunswick and Maine. Amer. Nat. 3:442-444.

Matthew, G.F. and Bailey, L.W. 1882. Sur les roches cambriennes du Nouveau-Brunswick. 2nd Int. Geol. Cong., Bologna (1881). Compte Rendu, pp. 646-648.

Matthew, G.F. and Kain, S.W. 1899. Artesian and fissure wells in New Brunswick. Bull. Nat. Hist. Soc. New Brunswick 17:143-152.

Matthew, G.F. and Kain, S.W. 1905. On an earthenware pot of the Stone Age found at Maquapit Lake. Bull. Nat. Hist. Soc. New Brunswick, 345-354.

ACKNOWLEDGMENTS

This compilation was completed during the tenure of National Science Foundation Grant EAR83-12939 (principal investigator, Ed Landing.)

MEETING ACKNOWLEDGMENTS

We are grateful to the following organizations for their financial support of the 1987 field meeting:

Canadian National Committee of the International Geological Correlation Programme (I.G.C.P. Project 29)

Natural Sciences and Engineering Research Council of Canada (N.S.E.R.C.)

Memorial University of Newfoundland

Queen's University, Kingston

New York State Geological Survey

The following individuals also contributed significantly to this meeting. We apologize for any inadvertent ommissions.

Technical Support and Publicity:

Alison Benus
Roberta Ellis-Hayes
Kathy Keicher
Grace Luce
Ann Mac Donald
Sandy McCracken
Felicity O'Brien
Grace Parsons
Douglas Wolf

Scientific Review:

J.D. Aitken	Institute of Sedimentary & Petroleum Geology
W.H. Fritz	Geological Survey of Canada
H.J. Hoffman	Universite de Montreal
M.A.S. McMenamin	Mount Holyoke College
G.S. Nowlan	Geological Survey of Canada
S.G. Pemberton	University of Alberta
R.K. Pickerill	University of New Brunswick

THE ORGANIZING COMMITTEE

Guy M. Narbonne	Queen's University at Kingston Voting Member, Precambrian-Cambrian Boundary Working Group
Ed Landing	New York State Geological Survey Voting Member, Precambrian-Cambrian Boundary, Working Group
Paul Myrow	Memorial University of Newfoundland Corresponding Member, Precambrian-Cambrian Boundary Working Group
Michael Anderson	Memorial University of Newfoundland Corresponding Member, Precambrian-Cambrian Boundary Working Group

CONTRIBUTORS

The following institutions, organizations, and individuals provided financial assistance in the publication of Bulletin 463:

Canadian National Commission of the International Geological Correlation Program (Project 29) (via D. Benson and G. M. Narbonne)

Faculty Research Grant, Colorado College (via P. Myrow)

German Research Foundation (via G. Geyer)

Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada (via W. W. Nassachuck and W. H. Fritz)

Ed Landing, New York State Geological Survey, The State Education Department, Albany

Guy M. Narbonne, Department of Geological Sciences, Queen's University, Kingston

National Science Foundation, Grant EAR83-12939 (via E. Landing)

National Science Foundation, Grant EAR85-18018 (via P. Signor and J. Mount)

87-7897

NEW YORK STATE EDUCATION DEPARTMENT
ALBANY, NEW YORK 12234

NON-PROFIT ORG.
U. S. POSTAGE
PAID
Albany, N.Y.
Permit No. 293

Bulletin Number 463
New York State Museum

ISSN 0278-3355
ISBN 1-55557-178-6

HECKMAN
BINDERY INC.
JAN 98
Bound -To -Please® N. MANCHESTER,
INDIANA 46962

SMITHSONIAN INSTITUTION LIBRARIES
3 9088 01300 8982